HIGH POTENTIAL AND HIGH FREQUENCY CURRENTS

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SNOW

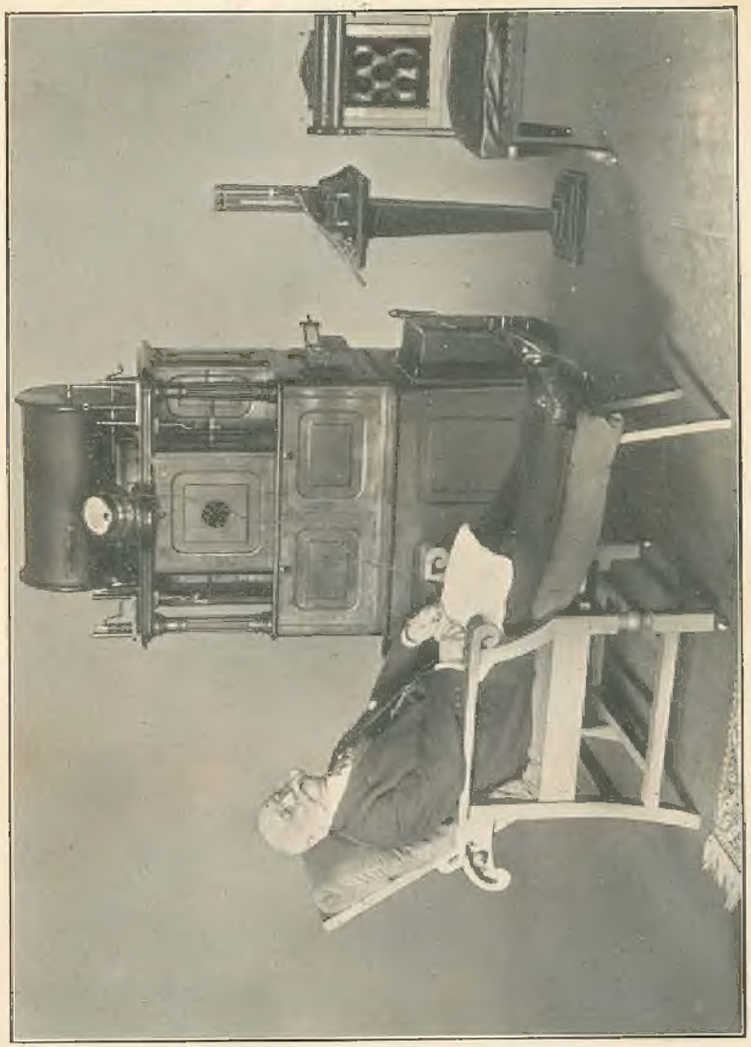

PLATE I. Auto condensation method.

# Currents of High Potential

## of High and Other Frequencies


BY

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Author of "A Manual of Electro-Static Modes of Application, Therapeutics, Radiography, and Radiotherapy," "Currents of High Potential of High and Other Frequencies," "Therapeutics of Radiant Light and Heat and Convective Heat," Editor of the American Journal of Electrotherapeutics and Radiology and Late Instructor in Electro-Therapeutics in the N. Y. Post-Graduate School, Etc.


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## PREFACE OF FIRST EDITION

THE study of the application of currents of high potential associated with variations in current strength and frequency as applied in therapeutics is engaging the attention of the medical profession as never before. Many valuable treatises have been contributed to the subject of currents of *high frequency and great potential,* but in no work published has due attention been accorded to *great potential* in association with the *lower rates* of frequency.

In view of the marked contrast in the physiological effects, in many essential particulars, of the different frequencies and for the purpose of calling attention to the relative actions of currents derived from different types of apparatus, it is purposed here to consider the high-potential currents broadly.

The author is sensible of the fact that in a field to which so many able writers are contributing, there is certain to be a diversity of opinion and development of new methods and apparatus. Noting that the value of many features and methods which have been demonstrated in his private and clinic practice has not been recognized by other writers, he is induced to add the same to the literature. Enough consideration has not been accorded by previous writers to the high-potential currents of the lesser rates of frequency, which have been demonstrated

to exert the most favorable effects upon acute and chronic inflammatory conditions, especially those in which no germs are present. It is the writer's object to show the reasons for contrasting these currents, and to endeavor to call attention to the importance of a degree of discrimination in other particulars not generally observed.

The vacuum tubes which have come into such general use during the past two years as one of the mediums for administering high-potential currents call for more consideration than has been previously accorded them. With the object of calling to the mind of the profession the broad scope of indications for their employment, many designs for special cases are presented as suggestions, with the realization that they will, in a few years, be replaced by others in many instances better adapted to many conditions.

WILLIAM BENHAM SNOW.

## PREFACE OF SECOND EDITION

DEVELOPMENTS in methods, apparatus, and the therapeutics of high frequency currents since the publication of the first edition of this work, has made it necessary to revise it throughout, and to add numerous cuts of the types of high frequency transformers and other apparatus now in use.

Of supreme importance in electro-therapeutic methods as in others is the establishment upon an accurate basis of standards as to the physiological action, effects and indications for the employment of the various modalities.

The physiological actions of the electrical currents and other physical agents when once clearly demonstrated and defined, become fixed laws for their practical and scientific employment. The writer has made every effort in his power in this direction in his study and employment of all modalities, with a view to determining the scientific relation of each modality to therapeutics.

In a paper read before the American Electro-Therapeutic Association in Boston, on September 18, 1907, attention was called by the writer to the importance of the establishment of *physiological laws in therapeutics*. The following year a committee devoted to the Standardization of Physical Therapeutic Measures began its labors. In this work the writer had the co-operation of able collaborators who have continued to assist in establishing a scientific basis for the employment of electricity and other

modalities. In this work the findings and standards adopted by that committee have been closely adhered to; and we believe will be found generally scientific and acceptable.

The writer wishes to express his appreciation of the cordial reception given the previous edition of this work.

WILLIAM BENHAM SNOW.

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### CHAPTER I

#### INTRODUCTION

THE study of currents of high potential has opened a field of far reaching scope and possibilities in therapeutics unrecognized by most physicians. This is true, and particularly to be regretted, of most of those who stand high in the councils of the profession.

A new science has been in process of development; employing technical means and principles with which physicians are not generally familiar—subjects requiring an extent of investigation which busy men are generally unwilling to pursue, preferring to devote their time to research in other directions.

The study of the employment of electrical currents, while technical, is not so difficult of comprehension that it would be a task for any medical man to acquire the requisite knowledge for their scientific employment. The consequence, however, with those who begin to use them without necessary investigation is frequent accidents or failures, resulting in subsequent prejudice.

It is not possible in a work of the scope of this volume to enter into the details of the physics or the sources of electrical energy. For such information the reader is referred to numerous works on physics such as Ganot's.

Before the preparation of the previous edition, the tendency was marked for men to put stress upon the use

of *high frequency currents*, ignoring the importance of the static currents administered with lower frequencies. It is with pleasure that at this time the author notes that the drift is to consider the subject broadly, attaching to each class of currents its specific indications for the relief of particular conditions.

The writer's investigation of currents of high frequency and high periodicity and the scientific progress that has been made by contemporary observers during the past five years, has led to a fuller conception of the importance of these modalities, and to the differential study of the varying qualities and effects of currents produced under different conditions with so-called high frequency apparatus.

The establishment of the claims of Prof. d'Arsonval with reference to the treatment of hypertension by the methods which bear his name fully justifies the claims of a few early observers, and it is probable that they will soon be recognized, if not adopted, by the profession at large.

Another action of high frequency currents associated with the induction of hyperemia on account of the thermic action of the current is now recognized by those familiar with the subject. The details of technique in this particular require careful study and consideration.

*The study of the high potential currents* from the standpoint of frequency and periodicity, especially for heat production, induction of hyperemia, and metabolic effects, seems to have established a scientific standard away from the theoretical; and the outlook at present is not in the direction of the production of particular frequencies so much as for the character of the current as to direction and thermic action. The establishment of this observation is in accord with the production of special physical effects;



not as to the vibrations produced, but as to the actions thermic, stimulating and alterative, which are due to conditions of current strength, and frequency.

*The superficial actions of the currents* in the induction of light frequencies, when passed through vacuum tubes, is a phase of the subject which calls for consideration as to the effects of the higher frequencies upon the blood.

*Local tissue destruction* is another indication for the use of the high potential currents, which has acquired a recognition by the adoption of successful technique during recent years. The employment of these currents for their destructive action upon abnormal tissue was first described by Riviere and termed by him *effluvation*. Kaeting-Hart, a student of Riviere, adopted this method, to which he applied another name—*fulguration*—the technique being the same. Later differential consideration of the discharges from the static current seem to have demonstrated a difference in quality to which Dr. Clarke of Philadelphia has called attention in a recent paper. The methods employed are of considerable importance; their value having been demonstrated for the removal of neoplasms, adventitious growths, and in the treatment of various conditions of the mucous cavities.

*The d'Arsonval methods*, or the modern methods of using the d'Arsonval current, occupy a very important place in the therapeutics of high potential currents. The auto-conduction and auto-condensation methods with the improvements by the manufacturers of apparatus by the increase of capacity of static machines, by increase in the number of revolving plates and the introduction of high speed machines, also with a larger number of revolving plates, has made it possible to produce upwards of 300

milliamperes as indicated by the hot wire meter when employed in connection with a resonator. Likewise with the improvement in coils and resonators, it is possible to produce currents of a milliamperage ranging from 300 to 3,000 milliamperes. With these currents it is possible to so affect arterial pressure by the auto-conduction and auto-condensation methods, as to render a most valuable service in the therapeutics of hypertension and arteriosclerosis; a place in therapeutics not adequately filled by any other measures.

*The increased recognition of these currents* for the relief of these conditions is one of the greatest advances made in the use of high potential currents in recent years, and demands the attention not only of electro-therapeutists, but of the profession at large, and the public as well.

*The thermic action* of the d'Arsonval current by the direct method is another important effect which is receiving more and more attention, particularly in the treatment of infectious processes, by inducing active hyperemia where infection is present. This method, likewise, is certain to receive a deserving general recognition, and should be investigated and employed in hospitals, research laboratories, and by the profession at large. Under the term *diathermy,* some recent investigators have enlarged considerably upon its use advising its employment in the treatment of neoplasms and other malignant growths. In this particular the effects resemble the methods by effluvation and oscillatory desiccation.

The place of static currents in therapeutics, still holds the important field for the treatment of non-infected inflammations; a field which from present indications can never be filled by other electrical methods.



These subjects are certain each to demand requisite attention and recognition, each in its own particular field, in conformity with the indications from a scientific professional point of view, and not from the point of view of the manufacturer who is often apt to assert incorrect opinions. Too often physicians in the past have been led into wrong notions or conceptions as to the methods and indications for employing the various currents by over zealous salesmen, who are often ready to take advantage of the credulity and flatter the conceits of the uninitiated who are disposed to investigate these subjects. Very often the manufacturers' suggestions in these particulars are erroneous and misleading to the physician who would succeed were he to adopt them in a properly scientific manner —first to know what he wants from those who are familiar with the subject, and then to select his apparatus, and adopt scientific methods.

Though fully conscious of the present status of scientific opinion as to the direction and other characteristics of electric currents as recognized by authorities, who teach that there is one electricity, and the opposite phase is the affinity of the non-charged atoms or molecules for the electrified particles or ions; the writer finds too many phenomena and physical effects that are derived from the employment of electricity, which do not substantially accord with the present theory to warrant its acceptance. The writer will therefore in this work treat the subject from the standpoint of positive and negative polarities, but recognize the modern view concerning current direction, which is clearly demonstrated to flow with the cathode stream from negative to positive as demonstrated in x-ray and vacuum tubes.

## CHAPTER II

### THE STATIC WAVE-CURRENT, PRINCIPLES OF ACTION AND THERAPEUTIC INDICATIONS

This valuable electric modality has been known to the profession for so short a time that we believe that relatively few have appreciated its pronounced effects and scope of general utility.

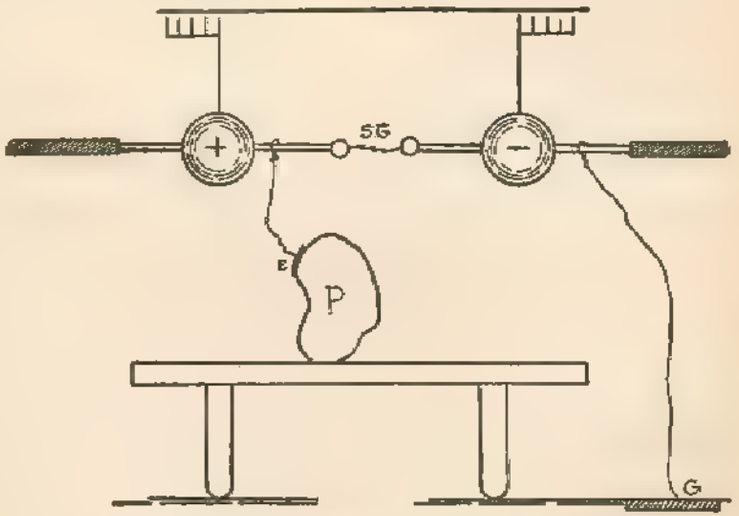


Fig. 1. Arrangement for the Static Wave Current. S. G. Spark-gap; E. Electrode: P. Patient: G. Grounding.

The arrangement for the current as shown in Fig. 1 was described by Jenks and Clarke in the report of the Committee on Nomenclature as follows: "In this arrangement, which the Committee believes originated with Dr. W. J. Morton, one prime conductor of the static generator is grounded; the other is connected with an electrode applied to the patient, who is on an insulated stand. The current received by the patient is due to the spark discharge between the knobs of the prime conductors. The patient forms one coating of a Leyden jar condenser, the other coating of which is the earth and surrounding objects and walls connected electrically therewith."



"The greater part of the charge and resulting strain on the dielectric, air, will be found at those parts of the patient and floor or walls of the room that are nearest together."

"If the spark-gap be long, the time of charging by the small continuous current will also be comparatively long, because the potential must be raised to a high point in order to produce a long spark. The duration of the discharge, which will probably be an oscillatory one of relatively high frequency, because of the small capacity of the condenser, will be short. The small continuous charging current will flow through the patient without causing appreciable sensation. The sudden oscillatory discharge may flow over the surface of the patient because of its high frequency, and therefore without disagreeable effects. As the length of the spark-gap is diminished, the time and amount of charge becomes less, with a resulting diminution of sensation."

It will be observed that in the arrangement for the administration of this current the following provisions are

made: (1) *An insulated platform*, for best results having legs 8 to 9 inches in length, and being about two and one-half by four and one-half feet in size, should be provided. (2) *A grounding chain* or metallic cord connected to some metallic path to damp earth, for which the house gas or water pipes are usually employed. In cases where such facilities are not convenient, a wire running to a rod driven deep into the cellar bottom will prove equally as good. (3) *A spark-gap*—the current regulator of potential of delivery—the distinctive feature of the static currents—is usually allowed to discharge between the balls of the discharging rods. When, therefore, the *spark-gap* is referred to, it is usually considered to be in this position. (4) *The connecting cord* and a *metallic electrode* connecting the patient directly to one side of the Holtz machine—the side opposite the grounding—completes the provisions.

The *static machine* should give a steady, uniform output of current and be operated at a rate of speed which will not give a *great* frequency as suggested in the above paragraph; lest " a sudden oscillatory discharge might flow over the surface of the patient because of its high frequency." Because in the administration of this current the physiological effects sought are those derived from the passing to and fro of the current, between the surface of the electrode and the whole surrounding surface of the body of the patient, surging back and forth, and from the local vibratory effects and muscular contraction induced in the tissues beneath the electrode.

*The distinctive characteristics* of the wave current, it



will be observed from the above description, are peculiar. (1) *It is a current of one polarity* (preferably the positive), administered to the patient from one side of the static machine, passing to and fro from the whole surface synchronous with the discharge at the spark-gap. (2) The *intensity of the discharge* depends to a marked degree upon the character of the grounding—a condition which it is not possible to effect with any current connected with a Ruhmkorff coil. (3) *The general diffusion* of this current, during the intervals between the charge and discharge of the current, are greater than from a current administered in any other manner with safety to the patient. (4) The current, when properly applied, is administered to the patient with the *absence* of any *disagreeable effects*, passing in and out of his body without any appreciable sensation except the moving of the hair, the vibratory influence, and the effects of muscular contraction. Care should be exercised to administer the treatment with the metallic electrode next to the skin of the patient, an intervening garment causing disagreeable burning sensations due to the passage of myriads of short sparks through the fabric. If the skin of the patient is very dry, at the commencement of an administration, there may be a burning sensation, due to the passage of short sparks through the dry epidermis. This is easily obviated by starting the administration with a short spark-gap, when shortly sufficient secretion will be induced to moisten the integument, or by first moistening the surface beneath the electrode.

*The physiological effects* of the wave-current suggest a

very wide range of application to therapeutics. In the first place, the current is absolutely innocuous,—harmless to the patient,—which makes it one of the most popular methods of applying electricity. This will be easily explained when we realize that the amperage is relatively so small that the possible damage to the patient from the quantity of current is reduced to a minimum—and that with a current of one polarity, though surging to and fro through the tissues, the electrolytic action is practically nil. Its effect, then, is purely mechanical with the added characteristics of electrical discharges. These effects are the induction of contractions which restore relaxed tissues to a condition of tonicity, in which condition they will persist for hours after the administration.

*Upon metabolism*, both local and general, the actions of this current are remarkable. The vibratory influence and recurrent intervals of contraction induce mechanically an activity of the end organs beneath the electrode stimulating secretion and excretion and tissue-building to a marked degree, and without harmful effects. Locally, conditions of *stasis* and stagnation are overcome, a local tonic condition of the arterioles is induced, promoting restoration to normal conditions where stasis has been present. These effects are not merely superficial but varied in their depth of penetration in proportion to the amplitude of the current, which is varied by increasing or slowing the speed of the machine and by lengthening or shortening the spark-gap. The physiological action, other things being equal, will depend to a large extent upon the character of the underlying subcutaneous



tissues. Layers of adipose or cellular tissue, owing both to the fact that they are poor conductors and muffle vibration, tend materially to interfere with the effects on the underlying muscular and glandular structures.

*Muscular contraction*, as suggested, may be induced to varying degrees from a *slight* vibratory tremor to a condition of extreme tetanus. The degree of contraction may be perfectly controlled by the operator, by varying the length of the spark-gap and to some extent by regulating the speed of the machine.

*Vibration* of a distinctly mechanical character is induced in consequence of the tissue contractions and by the influence of surrounding oppositely charged capacities, i. e., the walls of the room and objects surrounding the insulated platform, and may be intensified either by connecting the patient with any external insulated capacity, as a plate of metal suspended upon an insulated stand (see Fig. 2), or even by movements of the patient, as of the extremities, towards an oppositely charged capacity, as the opposite pole of the static machine, or walls of the room. The vibratory effect is undoubtedly also influenced by the sudden impact of the current discharging against the resisting skin, and the impulses of vibration are always synchronous with the discharge at the spark-gap. The depth to which vibratory impulses are transmitted, as with muscular contraction, will be varied by altering the length of the spark-gap, and the effect produced will depend largely upon the conditions of the underlying tissues,—a thick layer of fat offering

resistance to the current, and limiting the effects upon the muscular tissues.

*Contraction of cell protoplasm* is another undoubted effect produced by high-potential discharges at the site of administration. The degree or extent to which it is possible to carry this effect must depend upon the capacity for diffusion of the currents employed. Probably no current administered in therapeutics so universally pervades the tissues of the body as the static wave-current

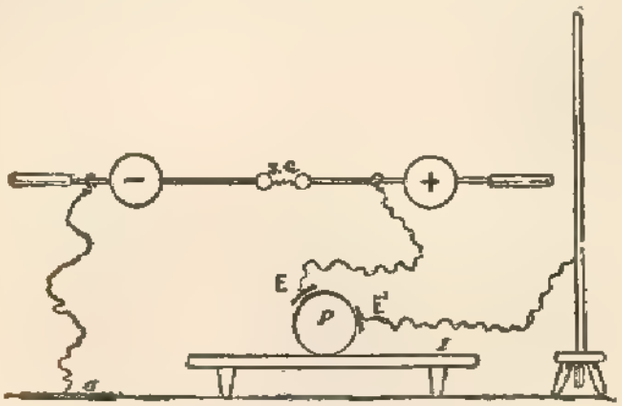


FIG. 2. Showing Arrangement with an Insulated Capacity.
I, Insulated Platform; P, Patient; E. Electrode; E', Second Electrode; G, Ground Connection; S. G., Spark Gap.

administered by means of an electrode applied to a small area. It must immediately pass through the body in every direction and surround the whole surface of the patient, passing in nearly straight lines. In its passage it produces universally effects, whatever they may be, peculiar to electricity, upon the tissues. The most intense effect of the current, however, upon protoplasm



must be in the tissues immediately beneath the electrode.

*The action of a current of one polarity* in passing through the tissues produces effects which differ from the other currents, which alternate between the two opposite polarities. During the to-and-fro passage of the wave-current all cells are like charged. While it is difficult to reconcile the idea of the separation of cells in tissues which are relatively homogeneous, still there is reason to believe that the cells, on account of this condition, are temporarily polarized, assuming different shapes and acting in ways which arouse activities capable of producing various alterative effects upon the tissues which they compose.

*The constitutional effects* of the static wave-current are pronounced, and from the study of a large number of clinical results, it has been demonstrated beyond question to be of great utility in the treatment of many conditions. The action will be best understood from the foregoing description of the *modus operandi* of the vibratory and other effects of the current as described. Undoubtedly these constitutional effects are largely due to the mechanical influences of the discharges and peculiar actions of electricity as described.

The evidences of an increase of general metabolism are marked by the restoration of normal functions, notably the activity of the secretions, followed by increased appetite and gain in weight and muscular strength, when properly associated with exercise during courses of treatment. The increased *elimination* of solids in the urine in

excess of tissue combustion is demonstrated in patients who have been inactive, and in whom the general nutritive functions are sluggish. With these cases it is the general rule that during the first weeks of treatment the percentage of solids in the urine is much greater than after the effects of poor metabolism have been eliminated. After some time this high percentage gradually falls off, but still a larger per cent. will persist than that present prior to the institution of the regular administration of the current. This is due to the fact that the general activities which have been restored produce an increased oxidation of tissue, coincident to normal healthy metabolism.

*On arterial tension* there will be, as indicated above, an increase locally during an administration, but the effect upon the general system, if the administration is prolonged, is to lower the arterial tension, noticeable in the changed character of the pulse. Coincident with this condition will be a lessened frequency and fuller rhythm of the heart's action and the normal associated changes in respiration.

*Upon the nervous system* the static wave-current produces changes in condition coincident with the altered nutrition and changes of circulation, as well as markedly diminished nervous irritability, and associated high tension, which is noticeable in the relief of muscular spasm and, to a marked degree, of nervous tension.

*Heat production* due to a greater degree of tissue oxidation coincident to general increase of metabolism is one of the remarkable effects of this modality, and one of the strongest evidences of its positive action upon a human



organism. In order to demonstrate this fact, which the writer had always observed to be pronounced when administering the current to patients for periods of twenty minutes to one-half hour, he made the following experiment: A patient was placed upon the static platform in a room having a temperature of 30° F. When the patient seated herself she was feeling chilled and her feet were cold. A large metal electrode was placed over the liver and solar plexus and the wave-current was administered in the usual manner, employing a spark-gap of four or five inches; at the end of ten minutes, the patient was feeling no discomfort, and at the end of twenty minutes was thoroughly warmed and comfortable. This experiment practically demonstrated the energetic effects of this current upon tissue metabolism and heat production.

*Upon the secretions,* the action of the wave-current is very pronounced. During the first administrations, when instituting a series of treatments of a patient having general sluggishness of the functions of the skin, there may be little or no secretion of perspiration during the first few treatments. There will, however, be a marked increase of the perspiration and other secretions in most such cases after several administrations. The evidence of the increased secretion of other glands, which as a rule resume coincidently with return of the secretion of perspiration, is demonstrated by the better performance of the functions upon which they depend.

It is easily shown with a patient whose digestion is impaired by giving a test breakfast, and two hours after

the meal taking the contents of the stomach for examination. On the following day give another test meal and at the expiration of one-half hour apply a flat metal electrode over the epigastrium, and administer the wave-current at this site for fifteen or twenty minutes. Two hours after taking the meal withdraw it for examination and compare them. Whereas the second meal will be well digested, the first will be found to be not nearly so completely digested unless the patient's digestion is normal. It is also observed with patients in whom the secretion of the liver has been pronouncedly deficient, that when the wave-current is applied over the organ, within a few days there will be marked evidence of an increased functional activity. The same is true of the kidneys, pancreas, and intestinal secretions. These results demonstrate the great utility of this current upon conditions in which the functions are inactive.

There are no evidences of fatigue or over-stimulation of the organic structures when administrations are given in normal individuals for from twenty to thirty minutes, but, on the contrary, increased functional activity, and in congested conditions a degree of inhibition is induced which deserves consideration from all earnest observers. A very prolonged administration, over forty minutes, may however produce a feeling of fatigue, which is always followed after a brief rest by a sense of well-being. No effect is produced that can be considered injurious even after very prolonged administrations.

A wide range of therapeutic indications for the use of the wave-current is suggested by an increasing evidence



of its worth, and probably no one therapeutic agent to-day occupies a field of usefulness so large, especially in conditions of local congestion and in its beneficial effects upon local and general metabolism. It has been frequently suggested to the writer that in his previous work on "Electro-Static Modes of Application and Therapeutics" he has not been sufficiently full in the explanation of this valuable modality, which is the apology for devoting so much space to its application here.

*The indications for its employment* in therapeutics, as suggested from the foregoing, are as follows: (1) the relief of local congestion and induration, and the elimination of inflammatory exudates; (2) the relief of pain, which is usually coincident with the effect upon the preceding conditions; (3) to relieve muscular spasm; (4) to lessen nervous irritability; (5) to correct errors of metabolism; (6) to generally increase functional activity, (a) by its action upon the secretory and excretory functions, (b) by the restoration of local muscular tone, thereby relieving atony, (c) by overcoming nervous and muscular inertia.

*Upon congestion and local hyperæmia,* as present either with acute processes or conditions of functional inactivity associated with sluggish metabolism, the effect is most pronounced. Probably muscular and tissue contraction and the induced activity of cell protoplasm excited by the action of this current by overcoming stasis, are especially effective in relieving congested and hyperæmic conditions. It induces with the recurrent contractions and relaxations an expression of the fluids and increased

activity, with the re-establishment of circulation in the tissues coincident with an increase locally of the metabolic functions of elimination and repair. The best results are obtained in these conditions by the employment of low rates of frequency. Probably discharges of one hundred and fifty to three hundred are the limit at which the interruptions should be permitted for the best therapeutic results in the treatment of inflammatory processes. It is appreciated by all who are familiar with the *modus operandi* of this current, in the conditions under consideration, that periods of rest between the intervals of contraction are essential to the attainment of the best results.

When we appreciate that congestions and hyperæmic conditions, associated with pressure upon the venous circulation,—acute and subacute congestions,—are the most common concomitants or causes of diseased conditions, we must admit the indications for the employment of currents of moderate frequency producing the mechanical effects of vibration and recurrent contractions. It is a draining process, the recurrent *vis-a-tergo* exciting activities that are invaluable in the treatment of inflammatory conditions. When the fact is realized that few diseases with pain, muscular spasm, functional neurosis, or other pathological conditions are not induced by inflammatory processes, the importance of the recognition of currents such as the wave-current and other modalities which induce resumption of circulatory drainage and repair, must be appreciated. A local lesion should be suspected and its character considered in all painful and functional de-



rangements, for in most instances the conditions may be referred to a coexisting inflammation. It matters not with the employment of the wave-current whether the congestion or hyperæmia is located beneath superficial muscular structures, as in sciatic neuritis, or in the deeper viscus or great glands of the body, under proper treatment. The amplitude of the oscillations of this current, when induced by a machine of proper capacity, is sufficient to penetrate remote parts and influence the denser, deeper tissues of the human organism except in very obese subjects. The author's familiarity with the work of many who have employed this modality with different measures of success, induces him to urge a more energetic and intelligent employment of the wave-current; for those who have not succeeded as they should, have employed it in an inefficient manner. The following rules of dosage, if carefully followed, are a sufficient guide for its successful administration.

I. *When employing the current for the relief of acute local congestion,* over the inflammatory area at the beginning of the first application, with but a short spark-gap, severe pain will be produced, which is caused by the contraction of the muscular structures including the muscular coats of the arterioles in the inflammatory area, producing pain by pressure. In a few moments, however, as the fluids are expelled, a longer spark gap can be administered with not greater discomfort than was at first experienced. In this way, by gradually lengthening the spark gap, and thereby increasing the amplitude and deeper penetration of the current, the more remote tis-

sues are reached, and the entire congested region more or less completely drained and the tissues left in a state of tonic contraction. The length of spark allowed to pass at the spark-gap during an administration will depend therefore largely upon the degree of discomfort produced at the time of the application and should be lengthened as the patient, tolerating a moderate degree of pain, permits it.

II. *In the treatment of deep-seated conditions,* where the congestion is not sufficiently intense to cause pain in connection with the administration of the current, and in *atonic conditions,* the guide as to dosage will be the degree of muscular contraction produced; avoiding the induction of an unpleasant or tetanic muscular contraction, but crowding it up to the limit at which this effect will begin to be produced.

It must also be remembered that an electrode large enough to cover considerable surface relatively diffuses the current, so that, when it is desired to get an intense local vibratory effect upon some lazy viscus, it will be necessary to make the electrode small enough that the maximum spark-gap to be obtained will produce an intense local effect. Many in the past have been negligent in giving the proper amplitude and intensity with the administration because of the noise of the discharge at the spark-gap or want of a proper appreciation of the requirements. The unfortunate disadvantage of the noise may be overcome by a properly constructed muffler, which will relieve this unsatisfactory feature of the administration (see Fig. 3). In the writer's experience,



however, nervous patients tolerate the noise much better than some physicians who treat them.

*These observations on dosage* apply not only to the administrations to inflammatory conditions, but to the applications of the current in all cases. It should be farther

FIG. 3. Glass Muffler.

added that the wave-current cannot be used entirely to the exclusion of the more rigorous static modality,—sparks. In some cases, as of deep-seated congestion and conditions associated with the presence of inflammatory exudates and when it is desirable to get a prompt response of the perspiratory function, the application of sparks and the superficial action of friction sparks will afford an additional benefit to the condition.

Attention must be called to the fact that there are certain inflammatory processes and conditions due to or associated with the presence of germs in which these static modalities will fail and are also contra-indicated, that is, in the treatment of local septic processes where pus is present, or where some other germ process is present beneath the integument. In such cases no static modality has proved efficacious. When pus is walled off

by surrounding induration, stasis is a protection against the extension of infection and must not be disturbed by the wave-current or any influence which will remove the *wall of safety.*

*In syphilitic processes,* gonorrheal rheumatism, tubercular processes, and infectious disease this modality fails, but will be found a valuable aid to diagnosis by exclusion in tubercular arthritis and gonorrheal rheumatism. If success follows the administration, such processes may be eliminated, as has been the writer's experience with tubercular joint affections. In all other than infected conditions positively beneficial effects are certain to result.

*Pain is probably relieved* by this and the other high-potential modalities which produce perceptible muscular contraction as by no other agent except morphine, because the presence and pressure of local congestion are relieved. In these cases, the relief is associated with a curative process due to the removal of inflammation; first, by overcoming local stasis, and, second, by the removal of inflammatory exudates, while with anodynes the relief is but temporary and never curative. The writer's observation in the treatment of painful neuroses has led him to believe that many of the pains of so-called "neuralgia" are not reflex but associated with remote inflammatory conditions. Pains, however, due to low grades of toxæmia arising from improper evacuation of the alimentary tract, imperfect metabolism, or malarial poisoning, cannot be strictly referred to inflammatory conditions. Such pains, however, are remarkably relieved by overcoming the conditions which caused them; for the relief of which, except malarial cases, probably no agent will contribute more than the static wave-current.



*Muscular spasms or contractions* of the skeletal muscles are certain to occur in connection with inflammatory conditions of the joints, disappearing upon removal of the causative conditions. Contractions, however, of cerebral origin, such as those of *athetosis,* do not respond to treatment. Many of the contractures associated with the functional neuroses, as of the uterus in cases of dysmenorrhea, respond very promptly to the administration of the wave-current, vacuum tubes, or static sparks.

*In conditions of nervous irritability* the origin of the trouble is found usually to be an inflammation located somewhere in the organism. It is therefore necessary to carefully diagnose the original condition and then make the appropriate administration. If this is done in a thoroughly systematic manner, there will be little difficulty in relieving most of the functional and many organic nervous conditions.

*General errors in metabolism* whenever present, either local or not, unless some organic condition precludes the possibility of restoring the normal condition, may be greatly relieved by these modalities. It may be wise, however, to combine with it in many cases the administrations of dry heat, light, or mechanical vibration. If, however, but one method of treatment were to be used in the treatment of sluggish conditions, there is no modality that offers so much for their relief as the static wave-current. For the treatment of these affections, the ad-

ministration should always be made over the organs which are the seat of the difficulty, or in doubtful cases it may be applied with comparative uniformity over the abdomen, employing an electrode about five by eight inches in size, placing it over the anterior portion of the liver, the epigastrium, solar plexus, and pyloric end of the stomach and pancreas, with a view to effecting an active metabolism and improving the nutritive functions.

*Activity of special functions* may be gradually accelerated by this energetic modality, bearing in mind that wherever muscular structures are present in glands, arteries, and other structures, the effect of inducing muscular and other tissue contraction, causing an expulsion of fluids locally, and coincidentally increases the general activity of the functions of the body, especially of those organs immediately beneath the electrode. Under this heading will be included an increase of secretion and excretion, restoration of normal blood circulation, relief of muscular atony, and the restoration of tone to the structures of the body.

*Conditions of nervous inertia* or general inactivity of function, so common in persons who lead sedentary lives without sufficient muscular exercise, will be generally overcome and their lives lengthened. These observations, which have been demonstrated by the therapeutic results in the treatment of hundreds of cases in the clinics and practice of the writer, are sufficient to warrant the general adoption of the wave-current and other high-potential modalities, especially those which produce a well-marked degree of perceptible tissue contraction.

# CHAPTER III

## THE STATIC INDUCED CURRENT

This current, the oldest of the high-frequency currents, was discovered by Dr. Wm. J. Morton of New York. It is described by the author as follows:

"From the earliest medical electrifications by the Abbé Nollet in 1734—we become familiar with the breeze, spray, sparks, and shock, but no mention is made of a current disassociated from the spark delivered to the person, nor prior to my own had any electrodes been shown by which a current, except in spark form, could be delivered from a Holtz or any other influence machine. When, in general, nerve and muscle reactions were spoken and written of, reference was had to galvanic and to faradic currents from coils and voltaic cells, or from coils and magnets, but not to any current derivable from frictional electricity. The spark and static electricity had become synonymous terms. That no one during one hundred and fifty years should have sought out the kinetic or current feature of the static discharge (in other than spark form) and harnessed it to an electrode capable of bringing it into use, seems most remarkable. . . .

"My new system, published and unpublished, comprises the development by an influence machine of a rapidly interrupted and graduated current, by means of a circuit-breaker, introduced into a circuit with and with-

out condensers, and in the medical applications of this current without and within the human body by moistened sponge or other electrodes, just as in the case of the ordinary galvanic and faradic currents.

" It involves the removal of the spark, in itself more or less disagreeable and painful and often difficult to localize, especially about the face and neck, away from the patient's body, and yet retaining all the physiological effects of the kinetic or current part of the circuit. The spark is no longer a direct feature of the administration; it occurs at some distant part of the necessarily closed circuit, and in modified form now becomes mainly a regulator for timing the discharge of the equalizing potentials.

" The circuit-breaker is a pair of adjustable metallic ball electrodes, introduced at any point of the circuit, having a narrow air space between the balls; the circuit makes when a small spark overcomes the resistance of the air, and breaks when it fails to do so, and the current is due to rapidly successive equalizations of the differences of potential of opposite charged condensers, with either the prime conductors or the addition of Leyden jars. . . .

" Accepting the fact that the rapidity of succession of impulses of the new current is in itself sufficient to produce a steady circuit, we may now go a step further and say that each impulse in itself consists of a vast number and range of oscillations or alternations (of one hundred millions per second); and, putting all the facts together, we may doubtless willingly concede that a current must



possess equally positive and differing physiological properties." . . .

" In his earliest publication upon this subject appear the following for physical results then noted. The event has shown that many of these were then imperfectly understood and appreciated, but the question before us is whether or not these observed results were in fact novel."

1. " By means of the spark-gap at the discharging rod, the imperceptible physical effects ' may be regulated to a nicety,' " from an almost imperceptible tingle up to the extreme rigid flexion of the arms.

2. " The effect is soft and agreeable and accompanied by no shock," while the inner coating of the jars gives a series of discharges which, even when slight, are " too painful to be borne."

3. " Capable of causing physiological tetanus," while a connection between the inner coating of the jars " in silent current forms produces no muscular contractions or sensations of any kind."

4. " When compared with the galvano—or magneto—induced current, both produce more efficient contractions and give less pain to the patient, when pain would be produced by any of the three."

5. " Renders a static machine capable of producing all the effects of faradism, doing ' all the work of the best faradic machines ' in addition to the ordinary static effects. ' In its general characteristics ' this current ' cannot be distinguished from the ordinary faradic current.' " *

* Extract from Report of the Committee on the Static Currents of the American Electro Therapeutic Association.

The acknowledgment of Morton's priority in the discovery of this current has been recognized by all recent writers upon the subject of high-frequency currents, including Tripier, Bourgoni, Leduc, Paschles, Ranney, Williams, Weil, Bordier, Freund, Jenks, Thompson, Herdman, and others.

The footnote from Freund * explains itself.

The following description of the method of employing the current and its physics by the Committee on Current Classification and Nomenclature was published in the Journal of Advanced Therapeutics for January, 1904:

"The patient is directly in circuit with the outside coatings of two Leyden jar condensers in series. The spark gap and machines are in multiple with each other. With the patient included in circuit in the manner shown in the diagram we do not know the value of the inductance and resistance offered by him. The arrangement of two condensers of small capacity is conducive to the production of oscillatory currents of relatively high frequency, and such currents will be produced if the patient offers a

*Extract from "Radio-Therapy," Freund; "In the year 1881 Morton described a method of using electricity for the local treatment of muscle and nerve disorders. He brought the terminals of the discharger of an electrical machine so near together that sparks passed between them. He then put his patient in the circuit connecting the tin-foils of the condensers. Morton was the first to produce by means of this arrangement and to therapeutically apply high-frequency currents, for he had used the oscillating character of the condenser-discharge to increase the frequency of an alternating current. The condensers were charged in this case through an induction apparatus. Morton's high-tension oscillating currents have been used by Leduc and F. Winkler in similar affections, and, of course, with results similar to those produced by other forms of high-frequency apparatus."



sufficiently low resistance and inductance. In the July, 1903, issue of Medical Electrology and Radiology, Dr. Manders expressed the opinion that the impedance (sum of the resistance and inductance) of the circuit including the patient may be so great as to render the current unidirectional by damping out the oscillations which the condensers of small capacity tend to produce."

"The term 'static-induced' applied by Dr. W. J. Morton to this arrangement, made by him in 1881, is techni-

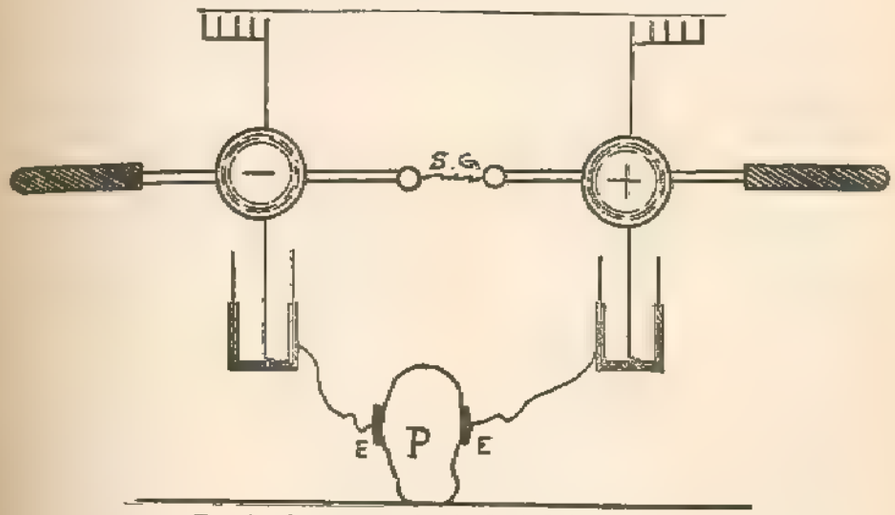


FIG. 4. Arrangement for the Static Induced Current.

cally accurate (Report of this Committee, see Journal of Advanced Therapeutics, Vol. XXII, Jan., 1904, p. 29). This term expresses the arrangement by which, as is now generally understood and conceded, currents of the character technically known as high-frequency currents were first produced, and applied to therapeutic purposes in such a way as to be tolerable to the patient; and on the

basis of which arrangement some subsequent arrangements are founded; for example, that of d'Arsonval, also those more recently devised by Dr. Morton."

*The physiological actions* of the static induced current include the actions described by Dr. Morton in his description of the current as given above. A wider conception of the effects of the current characteristic of the action of the high-potential discharges in the production of tissue contraction, however, widely enlarges the scope of its application. In this respect it is analogous to the local actions of the wave-current as given in the preceding chapter. An alternating current employing two metal electrodes, however, produces chiefly local effects—the electrical and mechanical effects upon the tissues beneath the electrodes and in the interpolar region between the two surfaces covered. The local actions, however, of this current are to effect in the same manner the relief of local stasis and sluggish metabolism as those of the wave-current.

*The static induced current,* however, possesses certain advantages over the wave-current which will arise in the experience of every practitioner.

*During periods of humidity,* when it is impossible to administer a spark-gap of sufficient length to produce the indicated local vibratory effect beneath an electrode, necessary to overcome local congestion with the wave-current, the static induced current having a more limited and localized field of action, and the added intensity of the characteristic condenser discharges, produce with a shorter spark-gap a much more profound local effect.



It is necessary, when employing this current, to make the applications to two different parts of the body. One may be placed over some part as an indifferent electrode, or may be valuable in the treatment of two parts, as both knees, in a very stout patient. In such a case an intense local effect will be demanded.

The application of two electrodes may also be of particular value in the treatment of a local inflammatory condition in one part and at the same time an additional application over some other part of the body where the functions are particularly sluggish, as over the liver or intestinal tract.

The static induced current may be used with two glass vacuum electrodes applied over two different parts of the same patient or to two patients at the same time, or with the vacuum tube at one part of the body and a metal electrode on another part. This plan of treatment will be found very convenient in the treatment of certain pelvic conditions where it is desirable to employ the metal electrode over the abdomen and the glass tube internally. (See Plate I, Frontispiece.)

Whenever two electrodes are applied at different parts of the body the local effect may be disagreeably unpleasant over one surface to produce sufficiently energetic effects over another. This may be easily regulated either by regulating the size of the metal electrode or by placing a larger sized Leyden jar in connection with the machine on the side where a more energetic action is indicated. By this means, with the three usual sizes of Leyden jars that are provided with the static machine, it is possible to

make very fine adjustments of the effects of the current in connection with each electrode. (See Plate I.)

It must be borne in mind that the static induced current, as indicated above, does not produce the constitutional effect upon the organism that is produced by the wave-current. It is not therefore indicated, except when necessary on account of atmospheric humidity, in cases for which there is no special indication for the improvement of constitutional conditions, or when time may be saved by treating two parts requiring an application of too great intensity to be treated at one time with the wave-current.

## CHAPTER IV

### DISRUPTIVE DISCHARGES, SPARKS

THE high-potential spark discharged either with or without the intervention of a resonator in connection with a coil or static machine, is one of the most valuable of the modalities employed in therapeutics; from the entire surface of a patient to the point of discharge the currents focus and escape, forming a vortex, as it were, leaving the tissues behind in a state of perturbation. Of this method of administration, but two modes, the usual ones, deserve consideration,—*the indirect spark and the resonator spark.*

*The indirect spark* is derived only from the static machine and may be described as follows: The patient is seated upon the platform, which is connected usually by a shepherd's crook from a metal plate placed upon the platform beneath the chair to the positive side of the machine (the negative connection is preferred by some operators). The opposite side should be grounded by means of a metallic connection with moist earth. (See Fig. 5.) The operating ball is connected from the screw eye of the metallic portion with another chain or other metallic connection also to the earth. With this provision it is not necessary that the operator be insulated from the metal connection, as no effect is produced upon him when administering the spark if the connection to the earth is

direct, as no appreciable part of the current will leave the better conductor to the earth for a poor one, as the operator standing upon the floor. It is customary therefore for the operator to hold the chain in his hand against the handle of the ball and at the same time, with the other

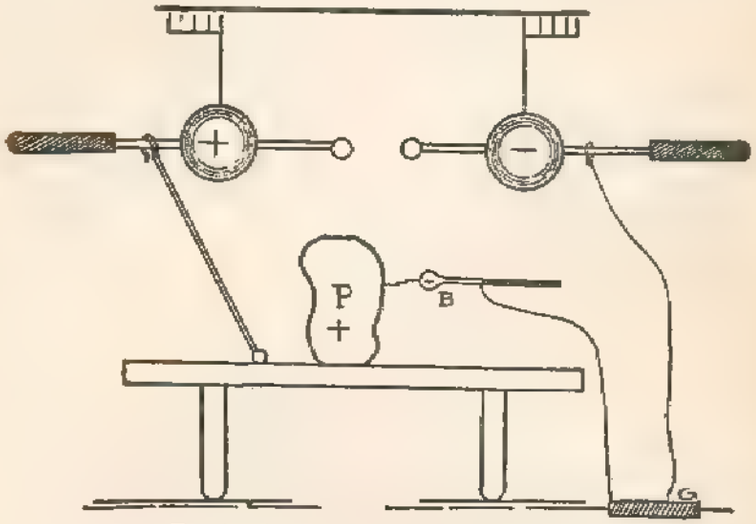


Fig. 5. Arrangement for Indirect Spark.

hand, hold it in such a manner that it will not be constantly thrown to and fro against the platform or the patient, interfering with the administration. The sparks may be administered of any desired length according to the indications—the longer spark for the deeper perturbatory effect upon the tissues. To regulate the length of the spark either move the shepherd's crook to the rear end of the platform, remove the metal plate which acts as a condenser, slow the speed of the machine, thereby diminishing the output, or close the discharging rods so that the



balls are separated to a distance a little greater than the length of the spark desired. By these means we will determine the *potential of delivery*, or the length of spark possible to administer, which should always be regulated to the depth of tissue which it is desirable to affect. The length of spark should vary usually from one-half inch for application to the fingers to four or five inches over the glutei and back of the patient, according to the depth of the tissue, taking into account also the amount of adipose overlying the muscular structures, the latter acting as a resistance and at the same time breaking up the vibratory effect and the influence of contraction upon the structures affected.

*A spark director* designed by the author, Fig. 6, is a

Fig. 6. Author's Spark Director.

practical device for applying sparks. It is provided with a long vulcanite or glass handle and two terminals of metal to be adapted to different surfaces and to admit of a varying degree of concentration or dispersion of the current to larger or smaller surface areas. A small ball and a disc, flat on one side, and convex on the other, which can be screwed to the end of the terminal, are provided for this purpose. The spark may be applied to the metal band at the lower extremity of the vulcanite handle or to the metal terminal in contact with the patient. See Plate II. The only disadvantage of this type of spark-director occurs when the sparks are applied over the clothing when if the handle is a partial conductor, as a wooden handle is, short sparks pass from the operator to the patient, be-

tween the terminal and the skin, when it is put in contact with the skin, or constantly while held over intervening clothing. This is generally obviated by the long vulcanite handle. Another device used for making the application of sparks in this manner is the crooked chain holder which has been supplied with most static machines, Fig. 7. By placing the curved end upon the surface to be treated so that the metal is in contact with more or less surface, it is possible to vary the intensity of the local effects, without changing the length of the spark. In other words when a larger surface of metal is applied to the skin, the same length of spark-gap produces relatively less intense

Fig. 7. Chain Holder Used as Spark Director.

effects upon the tissues. By means of these various devices, it is possible to administer sparks with varying intensity, and in the hollows or clefts or within the cavities to which it would be otherwise impossible to apply sparks. Another advantage in applying sparks in this way is that the moral effect upon the patient who sees a spark escaping from his person is often alarming, whereas, when the spark escapes to the metal part of the spark-director, though the effect is the same, the patient has not the same concern.

*The therapeutic indications* for the employment of static sparks cover a very wide range of conditions; for they include most of the inflammatory affections, excepting those associated with an infectious process. They are particularly efficacious in treating inflammations of the large

Plate II. Author's Method of Localizing Sparks.

and small joints, and for relieving the muscular tension and local infiltration of neuritis.

The idea so often expressed by physicians that static sparks are too painful, and that their patients will not submit to them, is mainly the fault of the operator and his method of employing them. In cases of brachial neuritis the infra scapular, triceps, deltoid and pectoral muscles are to varying degrees in a condition of muscular spasm, occasioning the patient discomfort, and pain on moving the arm. If in such a case the operator will apply sparks to these muscles directing him to move the arm or the part contracted following the application of a few sparks, the patient will soon become enthusiastic owing to the relief which they afford. There is no modality in which the matter of technique is of so much importance as in the employment of static sparks. The knowledge of the relation of inflammatory conditions to the induction of muscular spasm must always be considered as an indication for the application of sparks.

*In brachial neuritis* groups of muscles, as previously stated, are in a state of spasm. The application of sparks following the wave current for the purpose of relieving this tension, judiciously applied first to one muscle and then to another is remarkably effective; and the patient soon appreciates the value of the application; for day after day the pain becomes less, and the limb is moved with more freedom; and, following each application of well directed sparks the part is free from pain and tension, and a feeling of lightness replaces the sense of weight and the painful condition of the part.

*In cases of rheumatoid arthritis,* and other conditions of multiple arthritis or arthritis of a single joint, the

tension of the muscles in the vicinity of the joints and of the long muscles of the arm which pass to the fingers, is remarkably relieved from the discomfort and rigid condition in the joints involved by the application of sparks, conveniently applied by passing the sparking ball parallel to the tense muscles. This coincidently relieves the joint from the pressure thus exerted upon the interarticular cartilages.

In the case of a sprained ankle, within the first thirty-six hours after the accident the long muscles are in a state of marked tension; and in the chronic condition which follows the improper treatment of the sprain certain movements of the joint will be painful due to pressure upon the infiltration present between the bones particularly the malleoli and the astragalus, which will not be relieved except the spark be also judiciously applied along the contracted muscles. Long sparks applied by quick movement in which the ball is passed parallel to muscles in a state of tension or short sparks in rapid succession promptly relieves the tension and adds greatly to the comfort of the patient. The same is true of muscular spasm associated with neuritis; and the same treatment is indicated. No measure is so effective as the static spark in promptly relieving muscular tension.

Applications of sparks to the joints should always be directed to the internal tissues in the spaces between bony prominences, as around the patella in inflammations of the knee joint. A spark applied indirectly over the bone gives practically no relief to the joint inflammation; whereas, a spark applied to the soft structures over the intervals between the bony prominences lessens the infiltration and relieves the condition. The treatment of rheu-

PLATE III. Showing Static Resonator and Method of Administering Resonator Sparks.

matoid arthritis by the employment of the static sparks painful though they are, calls forth expressions of gratitude from the patient when they are judiciously and considerately applied.

*The regulation of the spark length* in making these applications is of most importance. To apply large sparks to small sensitive joints is painful and inexcusable. Sparks applied to the fingers and wrists should not exceed one-half to three-quarters of an inch in length; the former to the fingers, and the latter to the wrist joints. These are capable of producing all the good with a minimum of discomfort to the patient.

Fig. 8. Author's Pear-Shaped Ball.

*In the treatment of chronic inflammations of joints* and all cases of neuritis, there is little danger of applying too many sparks, except that they fatigue the patient; whereas in acute sciatica and other types of neuritis, the application of too great a number will often bring on a relapse, when a case had been satisfactorily progressing. This has occasionally occurred in the writer's experience, through the injudicious use of sparks by assistants.

For administering static sparks the pear-shaped ball, Fig. 8, designed by the author, is the most practical type. It was designed for the additional purpose of administering friction sparks to convex surfaces, for which purpose the so-called massage roller served awkwardly the purpose.

*Resonator sparks.* See Plate IV. Resonator sparks, or the sparks administered from a static resonator with a ball electrode, are generally indicated in conditions in which it is sought to bring about active hyperemia; but are in no respect equal in efficiency to indirect sparks in the treatment of inflammatory conditions. Whereas they were previously employed by the writer, they have been generally abandoned except in the treatment of skin affections.

# CHAPTER V

## THE CONVECTIVE DISCHARGES OR EFFLEUVE

The electrical discharges that are given off from metal points or from a relatively non-conducting material, as a wooden stick, either from a point or convex surface without the passage of a spark or disruptive discharge, are known as *convective discharges,* or the *effleuve* of the French.

*These discharges* are of a warm or hot burning character in proportion to the amperage of the current that is passing or the proximity to which the electrode is held from the surface of the body. *The direct coil effleuve* is consequently relatively hot, and unless held at considerable distance will generally produce, in a very short time, distinctly cauterant effects.

*The static discharges of this character* have been designated as the *spray* or *brush discharge.* The former is administered from a metal point, and the latter either from a metal or wooden terminal is passed through or over a wooden electrode. The latter material, offering a distinct resistance, prevents the current passing in a smooth discharge except when discharged from a point, when, other things being equal, it is much the same, but less irritating than the discharge from a metal point.

*The spray* is the oldest form of convective discharge and has been used by many operators in the past, both

from single and multiple point electrodes. (See Figs. 9 and 10.) Its characteristics, however, for the relief of inflammatory conditions, in which affections these dis-

FIG. 9. Single Point Electrode.

charges are usually employed, is not as effective as those of the brush discharge, which is therefore the elected means of employing the convective methods of treatment from a static machine. This method may also be administered from a low-frequency coil resonator.

FIG. 10. Multiple-point Wire Brush Electrode for Administering Spray.

*The brush-discharge* (a therapeutic expression in technical variance with physics), administered preferably from a green, unseasoned wooden electrode about 3-4 inches in diameter (see Fig. 11), serves a valuable purpose in therapeutics. The discharge has a distinctly disruptive characteristic, as if multitudes of little sparks were passing in rapid succession, producing a feeling when projected against the surface as if sharp particles of sand were thrown against the skin. This characteristic led Dr. Humphries to designate it * as a *disrupto-convective* discharge, which practically explains the character of its action. To this disruptive feature or impulsive character of the discharge is largely due its greater



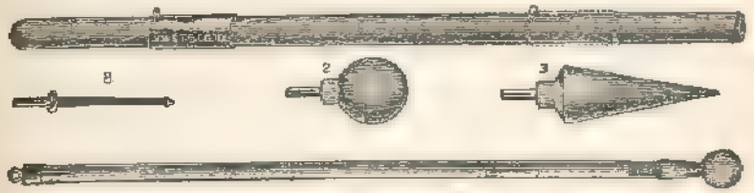


FIG. 11. Author's Set of Brush-Discharge Electrodes.
2 and 3, Wooden Terminals; 8, Insulated Metal Terminals, and Dr. Nealy's Glass Glycerine Filled Brush-Discharge Electrode.

degree of beneficial action in the treatment of superficial inflammatory conditions, to which it is so well adapted.

*This modality is administered* uniformly with the patient seated upon the insulated platform. The discharging rods should be widely separated and the patient hold the shepherd's crook in the hands or having the feet bare upon a metal plate, connected with the negative side of the machine, and the positive side should be grounded. It is demonstrated, and a well-recognized fact that when the patient is connected to the positive side, the effect is distinctly irritating, as well as aggravating to inflammatory conditions. The object in having the patient brought thus in direct connection with the machine is that the current may not be diffused too much over the platform and other part of the insulated portion of the apparatus be-

* See Dr. Humphries' Chart of Static Modalities, published by the Hospital Supply Co. New York.

fore passing to the patient, thereby permitting a much more energetic administration with a lower rate of speed, which latter may be varied to the demands of the case. If the wooden electrode does not permit a discharge of two or three inches between the surface of the patient and the end of the electrode, which is desirable for most administrations, the speed of the machine may be accelerated or the surface of the electrode may be dampened from time to time with a wet cloth held for the purpose in the hands of the operator. By the employment of moisture in this manner it is possible to apply these discharges from an old seasoned stick, but the discharge is never as smooth and satisfactory as when administered from an unseasoned stick. The wood of which these electrodes are made should be of some uniform texture not having a coarse grain, such as cottonwood, whitewood, basswood, or what is still better, the white portion of the sugar maple. The maple sticks do not dry out or season so rapidly as the whitewood or other soft woods.

*When administering the current* the operator should hold the sliding metal collar provided with the screw eye for attachment of the hook of the grounding chain upon the surface of the electrode, so that it reaches just beyond the finger, elsewise the discharges will produce a disagreeable, burning sensation to the hand. In lieu of a properly made collar, a few windings of a strip of soft metal upon the end of the stick, with the grounding chain passing to the metal, will answer the same purpose. The operating chain may or may not be connected to the earth, the current passing through the operator. This will depend upon the intensity of the discharge that is required. If it is desirable to get a pronounced effect the current should be grounded, otherwise, as in making applications about the eye, or within the ear or fauces, the machine may be run slowly and the current grounded through the person of the operator to the floor of the room. In this event the operator should avoid contact with metal conductors or suffer unpleasant shocks.



*A condition* which may arise when the static machine is running rapidly and prove unpleasant to the patient, will result from the passage of sparks arcing across on the interior of the machine which will cause very disagreeable contractions at the wrist. Under these conditions, the machine should be run at a lower rate of speed, and, if necessary to get the desired effect, the outer surface of the electrode may be made more moist. An unpleasant circumstance which may occur with the uninitiated, will arise from the passage of a spark between the balls of the discharging rods, which have not been widely separated. Another point to be observed is that when administering the brush-discharge the patient should sit directly opposite the pole to which he is connected,—the negative side;—otherwise the current will arc across, producing a burning sensation upon the surface of the patient nearest the positive prime conductor.

*During the administration,* the electrode in the hands of the operator should never be held in a fixed position, but should be moved about constantly over the surface to which he is making the application. This is done for two reasons:—(1) because the interrupted character of

the discharge administered in this way produces impulses of contraction in the underlying tissues, and (2) because the application from an electrode held in a fixed position is too severe to be borne by the patient. Under most conditions a wooden electrode after a time becomes carbonized through its length or certainly for a portion of the length, at the end nearest the patient. The discharge will then become similar to the spray given off from a metal point electrode. Under these conditions, the electrode should be thoroughly moistened over the extremity, when the discharge will again assume the *disrupto-convective* character producing the sense of hot sand thrown against the surface. The brush-discharge is one of the most valuable high-potential modalities, and the technique of application is not difficult if the above suggestions are followed literally.

*The effleuve from a coil* may be administered either from the coil direct or from a resonator. In the latter case the amperage is considerably diminished and the hot burning sensation much lessened. It may be administered from a metal point or carbon electrode, as the discharges of this character will not pass through the wooden electrode with sufficient efficiency to be of value. These discharges will vary in length and potency with the potential of the apparatus from which they are derived, and should be held at a distance at which the effect produced may be borne by the patient, when moved rapidly over the surface, the effect of which, as stated, is to produce a superficial hyperæmia. The effectiveness of these discharges in therapeutics, while valuable in producing a condition of hyperæmia, is rather too severe for application to most inflammatory conditions, except those conditions where a local cauterant action is desirable, as in the destruction of a local septic process which is superficial in character. If the coil current is used for the relief of inflammatory conditions, it is much more desirable to use the sharp resonator spark, which has been described in the preceding chapter; or from a modern electrode having a metal collar connected with a low-frequency resonator discharge, a brush-discharge may be administered if the surface of an electrode of wood is kept thoroughly moistened.



*The physiological action of the convective discharges* is of considerable importance.

*Rubefacience*—the production of a distinct redness—occurs when the application is made to one surface for a considerable time, occasioned by the irritation of the superficial capillaries. The effect of the discharges is very distinctively antiseptic on account of the heat produced, and also owing to the action of ozone and nitrous acid and the intense vibration effects of the discharges of light frequencies upon organic germ life.

*The action upon the tissues* of the interrupted convective discharges over inflammatory conditions is to relieve local *stasis,* softening the underlying tissues, by removing the induration that is present, thereby restoring normal circulation to the parts and instituting an active local metabolism. This effect is also followed naturally by a resumption of tone in the arterioles beneath the skin, which is shown from the fact

that there is no disposition to relapse, which would otherwise occur. When these discharges are applied over oozing ulcerated surfaces, the surface becomes covered with a coating or film, shiny in appearance—as if the surface had been brushed over with collodion. This is due to evaporation and the contraction of the superficial cells and forms a protection to the surface which will persist for a considerable time. When applied too intensely and for too long a time to a small surface, the discharges will produce a blister or an eschar, burning the tissue. These effects are produced most promptly by the larger ampere discharges from a coil effleuve. The only purpose that this effect will serve in therapeutics is the destruction of small areas, as warts, moles, or angiomata, and in cases in which there is a suspicion of local sepsis or the bite of a snake, or where an abraded surface has been exposed to septic infection.

*Rubefacience.* The general application of the discharges to the surface of the body, producing a dilatation of the superficial capillaries, will greatly relieve arterial tension and lessen the labor of the heart under various conditions, as those present in *arterio-sclerosis.* It also acts as a local counter irritant, relieving deep congestion under the general principles of the use of counter irritants. The indications for its use are in arterio-sclerosis as suggested, and over inflammatory conditions where, in addition to the effects, to be shown later, upon the deep congestion, the additional effects of counter irritation are produced.



*The antiseptic action* due to the cauterant oxidizing and chemical effects of nitrous acid and the intense vibrations of the violet discharges, though very superficial in their action, are sufficiently energetic to destroy certain types of infection, notably in superficial cases of lupus vulgaris and lupus erythematosus. The author has relieved a case of lupus vulgaris in six weeks and with no other application than that of the brush-discharge, which had been under treatment by various local applications for a year and a half. It must not be presumed that these convective discharges transmit the products of decomposition produced in a spark discharge or effleuve beneath the surface, or that it is possible to carry an ionizing influence beneath the integument. It must be also understood that the discharges are *from* the patient and not *towards* the patient as the appearance might lead the casual observer to suspect. Also, as stated above, these discharges are effective for the relief of local infection in the superficial layer of the skin when applied energetically enough to produce an almost cauterant effect upon the tissues, as over an infected, abraded surface, as suggested above. Another effect, which might be considered in a sense antiseptic, in that it admits the leucocytes and phagocytes to free access to an infection where an abscess will form, is explained in the following paragraph.

*The effect upon local stasis* of the convective discharges, when applied interruptedly passing the discharge to and fro, back and forth over the different parts of the surface where swelling and induration are present, is to generally soften the tissues. This is due

to the action of the discharges producing recurrent contractions of the tissues, thereby inducing an onward movement of the blood current through the vessels. Over superficial œdema as present in some cases of eczema and the swelling associated with bruises and sprains and where ecchymosis is present, the effect of these applications, systematically applied, is remarkable in its results. In conditions where local infection has set up an *abscess process,* as in felons (whitlows) and boils, the effect of the early application by overcoming local stasis and softening the tissues permits the blood to flow in freely through the area, enabling the leucocytes and phagocytes to destroy the infecting germs and restore the conditions to normal, where otherwise would supervene a painful abscess process. Nothing could be more gratifying than the results in these cases. The action upon local stasis is not only to relieve the conditions, but also to restore tone to the arterioles following the application, thereby preventing prompt relapse of the condition and furthering prompt and complete recovery. The application also undoubtedly stimulates end-organ metabolism and the elimination of effete materials, tending thereby to restore normal conditions in the shortest possible time.

*The indications,* then, for these applications are for the relief of all swollen and indurated conditions in which pus is not present in sufficient quantity to induce general infection by its escape into the general circulation, nature having provided induration for the walling off of a pus cavity. In cases, however, in which the infection is but slight the effect is, as suggested, to assist the leucocytes and phagocytes to relieve the system of the infection. It will require some careful discrimination on the part of the operator to determine the stage of the condition he has to deal with. As a rule, within the first two days of a felon or boil the relief of local stasis portends no harm to the patient from dissemination of the infection. In cases of tonsilitis, the result is most happy, if applied at the early stage, during the first day of the lesion, directly over the indurated spot, externally. The application should be continued until no induration remains, and repeated on the following day.



*The range of application* of these modalities also includes the superficial skin diseases, lupus vulgaris, lupus erythematosus, eczema, psoriasis, herpes, sycosis, favus, and numerous non-infected conditions associated with interference in the normal metabolism of the skin.

*In acne,* however, the application of the brush-discharge is not indicated, as the condition is not a local one, and it seems to cause a thickening of the skin without relieving the process when applied for a long time. In furunculosis it is also dangerous, as it is likely to drive the infection elsewhere, as it will if the application is made energetically to the surface. For these conditions, there are other means at hand,—light and the X-ray, which are as a rule effective.

*To ulcerated surfaces* the application of these modalities is one of the most valuable in therapeutics. Applied over the indurated margin, where it has a positive effect in removing stasis, it proves to be of the greatest

value for the relief of those conditions. The circulation is restored throughout the zone of induration which surrounds the ulcer, when a reparative process is immediately instituted.

*For application within the cavities of the body* the brush-discharge may be administered in connection with the glass sleeves that are shown in Fig. 12. These

Fig. 12. Glass Sleeves for Use with Brush-Discharge.

sleeves are slipped over the small prolongation tip (Fig. 13) which is placed in the end of the ordinary wooden stick electrode, and are designed for application to the

Fig. 13. Prolongation Tip for Use with Brush-Discharge.

cervix, in the fauces, and in the clefts as about the anus, where it is impossible to cause the discharge to pass directly from an electrode by other means. The sleeve may be moved to or fro on the end of the wooden stick, permitting a discharge of varying lengths to pass. The sleeve with tapered end is made for application to the ear, either for treatment of furuncles or for application to the drum or in otitis media, or the discharge may



be thrown into the middle ear for treatment of the affections present in suppurative otitis media. In these conditions, success must depend upon the extent of the lesions present and upon the proximity to which the discharges may be brought to them and the dexterity of the operator.

# CHAPTER VI

## HIGH-POTENTIAL CURRENTS WITH VACUUM TUBES

VACUUM tubes employed in connection with high-potential currents were first constructed of the Geissler type, having a wire passed from without to the interior of the tube. A later type which serves the same purpose is the plain vacuum tube without any metallic connection with the interior. Both types of tubes are made in various forms suited to the treatment of special conditions, and also having various degrees of vacuum. They may be employed with any high-potential apparatus provided with an interrupter, and do not necessarily require that the discharges be of high frequency. The term so often employed of "high-frequency vacuum tubes" is therefore technically a misnomer. While it is necessary that there be interruptions somewhere in the circuit of a current of *high potential* to produce these effects, high frequency is not essential. The term which should be employed in therapeutics with reference to these tubes should therefore be *high-potential vacuum tubes* if referred to therapeutics, or *vacuum tubes for use in connection with high-potential currents*. The tendency for terms to creep into medical literature which are unauthorized and unscientific, and which call for corrections and establishment later of a different nomenclature, has led to much confusion in the past.





*The phenomena* of the high-potential discharges having various degrees of interruption in connection with vacuum tubes are unique. That the effect upon a hollow tube having an attenuation of gases in the interior is associated with peculiar electrical phenomena, whereas one containing the ordinary atmospheric air is void, has led to a study of electrons as excited under conditions which are peculiar to the different degrees of vacua of the various tubes. That the vacua of these tubes may also be so highly attenuated that no phenomena are produced leads to another conclusion—that these effects are not due to the action of the current upon the ether, but upon the gases in the ether under definite conditions of attenuation, showing that it is necessary to the phenomena that there be present within the tubes gases of proper densities.

When a tube of the requisite attenuation is brought in proximity to a high-potential source of electrical energy, even when a short air-gap intervenes, it is illuminated by the phenomena of the cathode rays giving evidence of the presence of negative electrons within the tube, demonstrating an affinity of cathodal high-potential electricity for the attenuated gases within these tubes.

The fact that the negative electrons of high-potential currents are attracted to certain degrees of atmospheric attenuation may explain some of the phenomena in the rarefied portions of the atmosphere.

*The characteristics of these electrons* are described by Sir Oliver Lodge in speaking of the cathode rays * as

* Archives of the Roentgen Ray for April, pages 185, 186.

follows: "It is from these rays (the cathode rays) that most of the others are derived. It is owing to a study of their nature that so much advance, almost of a revolutionary character, has been made recently in the science of electricity -advance which must have a perfect bearing. *The cathode rays* are flying electrical particles called electrons—actually particles—I cannot say particles of matter because *they appear to be particles of which matter is composed*, they are particles of electricity. We now know that electricity is really an atomic thing in the sense of having actual particles, and these particles are called electrons. They fly along in the cathode rays. Their motion constitutes all electrical currents. They go round in magnets and are in fact the substitute, the substratum of the whole electric science. When they are intercepted they give rise to radiation; when they revolve they also give rise to radiation. It is their acceleration which excites all radiation, and when they are suddenly stopped, as when impinging on a solid target, they give rise to X-rays. Wherever you have these flying electrons, these cathode rays, sometimes called *Beta rays*, where they constitute one variety of radiation from radium—wherever you have these rays striking and stopped suddenly—the X-rays take their origin." The positive ions are described by the same writer as "slow moving ions of large size," or "heavy things which we are beginning to consider as quite a massive sort of thing,—they get to the cathode and in that way complete the circuit." It seems, therefore, that the important element in the effects of these vacuum tubes is the negative ion or cathode electron, and that the positive ions, while essentials to the presence of the inductive and electrical phenomena, are far less significant than the rapidly moving negative electrons.



There has been much argument and controversy as to whether electrons pass through the glass of the vacuum tube. Sir Oliver Lodge in the same paper affirms that the "negative electrons do pass through the glass." He says that, "these electrons in the cathode rays themselves may be emitted through the tube, too, and as a matter of fact, in addition to the X-rays, a certain number of Beta rays or cathode rays are emitted." "It is owing to the escape of these electrons that the vacuum has a tendency to go up gradually as the tube is used, and the tube thus has a tendency to become practically useless." Again he says that, "matter seems really to escape through the glass in the shape of atoms of electricity, for it cannot get through except in the forms of electrons. The constituents of the matter escape, and thus the matter itself escapes. If you hold an electroscope near the bulb, you will get the effects showing that these electrons are escaping."

He gives another explanation of the phenomena as follows: "It appears that some of the electrons pass through the glass, for if a proof-plane be held anywhere in its neighborhood negative electricity can be collected, provided the proof-plane is removed quickly enough, or the tube simultaneously stopped, so that its ionizing power shall not discharge the proof-plane."

It may be easily demonstrated that the phenomena pro-

duced either within a vacuum tube having no leading-in wire or a Geissler tube, are exactly the same when connected with a high-potential source of energy, indicating that the discharges which pass to the collar of the tube holder connecting the vacuum tube to the source of energy must pass through the glass to the interior of the tube, the same as when a metallic connection enters at the corresponding end of a Geissler tube. For example: if a vacuum tube, having no leading-in wire, be connected by the usual method with a connecting wire to the negative side of a Holtz machine, or a Ruhmkorff coil, the discharge—the cathode stream that passes to the opposite end of the tube—will produce a green spot of fluorescence, if the vacuum of the tube is of sufficiently high vacuum, at the end where the cathode rays impinge, indicating the presence of the X-ray. The same effect will be produced in the end of a tube of the same vacuum having a leading-in wire connected, also, to the negative pole. If either tube is placed against some substantial object, the green fluorescence is immediately transferred to the side of the vacuum tube opposite the place of contact. Another experiment may be made by connecting the positive pole of a Holtz machine or a Ruhmkorff coil with the two kinds of vacuum tubes. The green fluorescence appears at the other extremity of the tube beneath and around the metallic holder of the vacuum tube, or at the place where the wire enters the Geissler tube. It would seem, therefore, that these two experiments produce precisely the same phenomena, whether the current is conducted to the interior of the tube by a metallic connection or not, indicating that the electrons are admitted through the glass of the tube. These demonstrations and the experiments of Sir Oliver Lodge seem to demonstrate that the negative electrons do pass through the glass of the tube, not exceptionally but invariably.



*The various color effects* that are produced within the vacuum tubes when the negative electrons are passing, depend upon the degree of the vacuum, except that the volume or richness of the color will be greatest from the sources of large amperage. The color produced, therefore, will be the same in any tube, from whatever source, regardless of quantity or the range of potential that will induce them. It will depend upon the vacuum of the tube, which indicates that various rates of ether vibration are induced by the passage of the cathode rays through media of varying resistance, up to the point where the vacuum becomes so high that these rays cease to pass, when no effect whatever seems to be produced. At this point it is probable that the electrons cease to pass.

*The effects of frequency upon the phenomena* are evidenced by the observer in recurrent waves of color, which pass synchronously with the rate of the interruption. These waves of discharge are capable of exciting vacuum tubes, which are made to revolve or oscillate back and forth, showing groups of discharge in lines the size of the hollow of a revolving or oscillating tube, varying in number with the rate of the condenser discharges at which these interruptions occur. To demonstrate this effect take in the hand a narrow vacuum tube connected with a high-potential source, having means of varying

the rate of condenser discharges, and cause it to oscillate back and forth, and note the effect. Groupings of one, two, three, four, or five, or more of these lines of color may be made to appear by varying the frequency and rates of oscillation.

*The waves of cathode rays* passing with the negative electrons will flow, if the tube is connected to a source of sufficient energy, in recurrent clusters or groups of oscillations passing through the dielectric to the object. These waves are synchronous with the interruption at the spark-gap of a static machine or resonator, or a mechanical interrupter of a Ruhmkorff coil. For making this experiment a very small vacuum tube may be attached to the stem of a metronome, which may be regulated to oscillate at a given rate.

*The chemical effects of these vacuum-tube discharges* are the production of various combinations characteristic of electrical discharges in the atmosphere—derived from the expenditure of energy upon the air, and a change in the conditions of electrons now known to be substantial things—producing $NO_3$, $O_3$, $H_2O$—and other products of less significance. The color of these discharges as they pass through the air is usually violet, but varies somewhat with the intensity of the discharges to almost white. Various other physical effects are produced which depend upon the sources. When connected *directly* to the static machine, discharges through short air-spaces produce a decidedly irritating and stinging sensation as they escape from the surface. The discharge is in bunches or multiple oscillations, in number relative to the length of the air-



gap between the tube and the patient, the frequency of the spark-gap discharge, and the volume of current passing. When discharged from a resonator, however, the potential of delivery, the spark length that can be administered, will be slightly longer than the spark-gap between the condensers of the resonator and be accompanied by a multitude of less intense oscillations and frequencies. These discharges will vary with the type of resonator or solenoid and current source employed.

*The convective discharges* from the vacuum tubes, when derived by direct connection with a Ruhmkorff coil, are very numerous and produce a severe burning sensation, unbearable when held at a short distance from the skin.

*The color of the convective* discharges varies with the intensity, i. e., the color of the discharge between the tube and the body.

By connection with resonaters and solenoids the intensity of these discharges may be greatly varied and the number of oscillations greatly multiplied, giving these currents, as well as those of the static machine, the right to be termed high-frequency discharges, i. e., from the standpoint of the great number of oscillations emanating from the apparatus.

*The physiological effects* of these vacuum-tube discharges are varied, depending upon the source of electrical energy and the character of the resonator or solenoid, which intervenes between the exciting apparatus and the surface to which the discharges are applied.

(1) *The effects are of a stimulating character,* produc-

ing a local irritating action which stimulates the superficial tissue when applied, because of the immediate irritating effect of the discharges, and are distinctly rubefacient. Locally there are also the effects of the chemical action of the discharges which are produced by the passage through the air or dielectric. These stimulating effects to the periphery, especially when applied to motor points, produce reflex muscular contraction, as well as other reflex effects, to which undoubtedly the constitutional, clinically demonstrated, action of the discharges from vacuum tubes may be largely attributed. When, however, the application is made to the surface of the body, either with the patient holding an electrode connected with the resonator, or when the electrode is applied without such contact, the patient receives inductively and conducts from the surrounding capacity to the point of discharge currents of equal potential of the opposite polarity throughout the tissues of the body from the periphery to the electrode.

(2) *The rubefacient effects* of these discharges are pronounced in character, and when excited by the vacuum tube held a short distance from the surface or from the spark of the resonator, they produce a marked degree of local counter irritation and more, because the local effects of these discharges are clinically demonstrated to influence metabolic processes in the integument, restoring, to a remarkable degree, normal conditions. The action may be carried, however, so far as to produce distinctly cauterant effects.

They may be so administered as to cauterize the tissues



from almost any source, the time required varying with the amperage of the current, other things being equal. That this action should be considered as comparable to the X-ray, as one author has suggested, is a serious mistake. That necrotic conditions are exerted by both is admitted, but as well say that the application of an actual cautery produces the same effects as the X-ray when their actions and effects are entirely different.

(3) *The antiseptic action* of these discharges is due to the influence of the chemical products of the discharges produced by the passage of electricity through the air-gaps, and the action of the actinic rays associated with the discharges. The radiations have been reported by various authorities as penetrating the tissues from one to three millimeters. They are peculiarly effective in the destruction of germs which are susceptible to the influences of light, as are the gonococci. The extent, however, of the antiseptic action has not been fully demonstrated. The chemical effects of the products of atmospheric and electric decompositions are fairly energetic, when brought in close relation with the tissues, as when vacuum tubes are placed in the cavities of the body, when, to obtain the best results, the glass should be large enough to smooth out the rugæ of the mucous cavities in order to bring the discharges in immediate contact with the germs that may be present. The nascent nitrous oxides are produced in such infinitesimal particles that even when it immediately unites with the water present and forms nitric acid, it is not produced in sufficient quantity to cause disagreeable irritation to the tissues unless the adminis-

trations are prolonged. The time of application may be varied, however, from five to fifteen minutes according to the amperage of the current employed. The current of larger amperage produces a much richer discharge and consequently one which is productive of a greater degree of chemical effect.

(4) *The analgesic action* is due largely to the effect upon local inflammatory conditions. There is also an anæsthetic or numbing influence upon the superficial tissues, which relieves to a large extent local irritability, and by causing an ulcerated surface to become superficially covered with a glossy film (resembling a coating of colladion) which remains after the applications, thereby protecting the surface from local irritation.

(5) *The effects upon local metabolism* are due largely to the induction of muscular and tissue contraction and the pulsatory influences, coincidently affecting local stasis and congestion. These effects are most marked when the vacuum electrodes are in contact with the tissues, and the current is produced by direct connection with the static machine (with coil currents active contraction is not produced). By this means existing induration and infiltration are dissipated, the tissues become softened, and the circulation is restored as to the margin of an ulcer and local *repair* is instituted. The same influence produces an increased elimination of the products of inflammation, thereby assisting the process of reconstruction. Congestion is relieved and restoration of ulcerated and indurated regions to a normal condition is effected, in cases which are not malignant or too chronic or deeply seated in character. When application is made repeatedly, with vacuum-tube discharges, to the surface of the body, the skin beneath the epithelium becomes pigmented, a condition which may persist for considerable time, but is, as a rule, finally absorbed as is tanning by the sun's rays, to which it is analogous.



(6) *Muscular and tissue contraction and local pulsation* are produced by these vacuum-tube discharges to a marked degree when derived directly from one side of the static machine, when a spark in the circuit is discharging at the spark-gap. These effects of muscular and tissue contraction and local vibration, so valuable in therapeutics for the production of increased local metabolism and elimination, as well as the restoration of muscular tone, *are not so well produced by connection in any other manner or to any other apparatus that has been produced, as to the static machine in the manner above described.* It should be understood that it is not necessary that the patient be insulated during the administration of this modality.

*The muscular contraction and vibration* produced in the above manner is greatly accentuated by grounding the opposite side of the machine—the one not connected to the patient. Muscular and *protoplasmic* contractions reflex in character may also be induced by convective discharges when applied to the surface from the tube held at a short distance. The sparks administered from a resonator, or solenoid, either with a coil or static machine, will produce marked muscular and protoplasmic contraction.

*The indications for superficial application* are for the treatment of local skin and superficial inflammatory affections. The administration of the coil or resonator currents from the vacuum tubes in close contact with the tissues produces to a very slight extent, if any, appreciable muscular contraction, and they are not sufficiently energetic to be of therapeutic value.

There is a marked contraction of superficial cell protoplasm from the resonator sparks from either of these sources, and owing to the larger amperage of current, this is more marked in a given length of time from the coil than from the static machine. The effect of this modality makes the coil current valuable, also, in the treatment of superficial inflammatory conditions.

Those who employ coils, as shown in the reports of results in the writer's possession, obtained from numerous observers employing vacuum tubes, are having a smaller percentage of success from the treatment of inflammatory conditions—either those employing the coil or static currents from resonators—than those who employ the current directly from one side of a static machine, employing the usual grounding to the opposite side. In this connection it should be emphasized, then, that whenever it is desirable to produce this effect of tissue and muscular con traction and vibration for the relief of local inflammatory conditions, the current should *not* be derived from a resonator or step-up coil, but when possible *directly from the static machine, one side of which is provided with a good metallic grounding.* This is an important observation in connection with the application of vacuum tubes and is



the indication for the choice of methods for the treatment of non-malignant, suppurating, or tubercular conditions when not too deeply seated. The latter demand the more energetic modalities—the wave-current or indirect sparks.

(7) *The local production* of heat arising from the action of the current is due to the chemical influence of the discharges in the very minute air-spaces which exist in the tissues, and to the effect of the heating of the glass from the passage of the discharges. Some heat is also, undoubtedly, produced by the passage of the current through the tissues and is insignificant or marked, relative to the amperage employed.

*The therapeutic indications* for the employment of the vacuum tubes, as suggested by the foregoing physical and physiological effects, is important, especially, for the treatment of superficial skin conditions and ulcerative and inflammatory processes in the cavities of the body.

(1) *For the relief of superficial local congestion and induration,* as suggested above, satisfactory results are obtained. The method is especially adapted to affections of the mucous surfaces and is usually administered by applying the vacuum tubes in close contact with the tissues. The current of the static machine, when employed in these cases as the source of the high-potential current, accomplishes the best results. Those who employ coils may obtain excellent results, though not equally good, from the use of the vacuum tubes in these conditions. With the static machine these vacuum tubes may be used either as described, connected directly to one side of the

Holtz machine, the opposite side being grounded, or it will be found convenient in many cases, and equally good results may be obtained by connecting it directly with the outer coating of one of the Leyden jars, when using the static induced current. A metal electrode may then be placed, if desirable, upon one part of the body of the patient, and the vacuum tube in position in the rectum or vagina, or, if desirable, two vacuum tubes may be used simultaneously. When this is done, either with one metal electrode or two vacuum tubes, the local effects may be regulated by varying the sizes of the Leyden jars, which are connected to the two electrodes; for example, if a metal plate has been placed upon the abdomen, or over the liver of the patient, and another one in the rectum for the treatment of a local condition in that region and the machine started. (See Plate IV.) When regulating the current to the demands of the case, a distinct vibratory effect should be appreciated in the rectum. If to induce this effect too great muscular contraction is produced beneath the metal plate which has been placed upon the abdomen, a smaller-sized Leyden jar should be placed upon the side to which the cord connected with the electrode on the abdomen is attached, or a larger one may be placed upon the other side and a shorter spark-gap employed. By using the three sizes of Leyden jars provided with static machines and varying them to suit the conditions, it will often be possible to produce desirable local conditions without discomfort to the patient. By variously regulating the application of the current, two patients may be treated at the same time with the static



induced current, if it should be desirable to do so for economy of time.

*Another method of producing muscular contraction* for the relief of local congestion—the method which is employed successfully to the surface—is to apply the sparks from a high-potential resonator in connection with a coil or static machine. The application of these short sparks, from either source, should be made to the parts affected, but should never be made too painful. For using this method with either high-potential resonators or solenoids, the apparatus should be capable of delivering sparks one-half to one and one-half inches in length. These may as well be applied when using a static resonator from a small brass ball, when the sparks are more energetic. The effect of contraction from these applications is most marked—especially of cell protoplasm, the tissues taking on a condition of marked contraction expressing serous contents from the œdematous tissue or pustule, thereby rendering a valuable service in the treatment of various skin conditions. These applications are valuable in the treatment of felons, tonsilitis, and other abscesses in the early stages; for the relief of congestion in the small joints, as in cases of the treatment of rheumatoid arthritis, for the production locally of small blisters, for the removal of moles and freckles, and in the treatment of numerous skin diseases, notably the types of lupus, eczema, superficial ulcers, angiomas, etc.

(2) *For the restoration of normal secretion in the skin* and mucous cavities to which the application is made, these high-potential modalities are valuable. The same

rule obtains here as in the treatment of inflammatory conditions with reference to the production of local tissue contraction and vibration, the vacuum tubes with static current and relatively painless resonator sparks, static or coil, producing the best results.

(3) *To relieve excessive secretion,* restoring tonic conditions to the tissues by the production of contraction of cell protoplasm with the expression of redundant secretions such as are found in eczema, no measure is more valuable than the short resonator sparks applied extensively over the affected region. The parts will continue to ooze for a considerable time after the cessation of the administration, so that subsequently the reduction of the œdema will be marked. For the increase of superficial local metabolism the application of the resonator sparks is effective by the induction of vibration and muscular contraction.

The relief of swelling and induration and institution of tissue repair are remarkably demonstrated in the treatment of ulcerations of accessible mucous cavities. The administrations are especially valuable in the treatment of various ulcerative and congested conditions in the cavities of the body with the vacuum tube in contact with the affected areas. Externally the application of the short resonator sparks produced by the so-called high-potential apparatus, alone or in connection with a solenoid, are to be preferred if the vacuum tubes are to be employed.

(4) *To the treatment of local specific conditions* in which the parts affected are superficially located, no modality affords better promise of success than the small



resonator spark, either from the vacuum tube or a metal or carbon electrode. In the treatment of these conditions the necessity for a current which will produce muscular contraction and vibration is not so important. Where conditions of impaired metabolism are present, vibratory and contraction effects, however, do promote the elimination of effete and toxic materials, and increase local leucocytosis, thereby facilitating the restoration of normal conditions. The antiseptic effects are due, as explained above, to the chemical products of the discharges, as they are produced in the interstices in the superficial structures by the decomposition of gases, to the action of the rays of light upon the tissues and the germs, to which in many cases they are destructive, and to the increased resistance of the tissues. By these methods the processes which are acting as local sources of irritation are destroyed and reparative action instituted.

(5) *The cataphoric action* of the vacuum-tube discharges when the tubes are placed in close relation to the tissues, or from the application of the resonator sparks, has been demonstrated by Drs. Francis B. Bishop and J. H. Burch, and may be verified by anyone who wishes to make the experiment. The extent, therefore, to which this sort of action is valuable, is one open to careful study. The indication for the use of iodine or other local germicides in the treatment of specific conditions will depend upon the failure to succeed by simpler methods. Failing to relieve the conditions by the application of high-potential discharges alone, it will certainly be proper and scientific to resort to the employment of cataphoric methods, mild

though they be. Marked success has been obtained in the treatment of Riggs' disease by this method.

(6) *For the relief of pain,* the same general principles obtain as for the relief of inflammatory conditions, with the advantage also that these applications produce, as stated above, a coating upon the outside of the surface due to the contraction of the superficial protoplasm. This effect in a large measure resembles a coating of collodion which protects the ulcerated surface against irritating secretions. Conditions of neuralgia, arising from impaired elimination of toxins, due to various causes, may be relieved by either general or local applications of these modalities. For the improvement of local metabolism, these and other high-potential methods of application afford a valuable means. For the effects upon general metabolism local applications of this sort, however, are not of nearly so great value as other methods of applying these currents.

The field of indications for the employment of vacuum-tube discharges as suggested is large indeed and worthy of general recognition by the medical profession.

# SECTION II

## HIGH FREQUENCY MODALITIES AND APPARATUS

# SECTION II

## HIGH FREQUENCY CURRENTS AND APPARATUS

### CHAPTER I

#### COMPARISON OF CURRENTS OF HIGH FREQUENCY AND HIGH PERIODICITY

THE professional understanding of high potential currents of high frequency and high periodicity, is so vague in the minds of the rank and file, as to the exact quality or character of current considered under the designation, that the writer will attempt to make clear the relationship.

The Committee on Current Classification and Nomenclature consisting of the distinguished physicists Dr. A. E. Kennelly, Prof. Elihu Thompson, Dr. Samuel Sheldon, Prof. William Herdman, M. D., Mr. W. J. Jenks, and Mr. Charles L. Clarke, in their report before the American Electro-Therapeutic Association in 1904, on page 81 of the published reports of the Committee, fully outlined and defined the conditions under which oscillatory currents and pulsatory currents are produced.

*An oscillatory current* is defined in the report of Jenks and Clarke as "A current which periodically flows in opposite directions, but not necessarily in both directions for the same length of time, and in which the maximum values or amplitudes, of successive waves (irrespective of the direction of flow) change in regular order. In an oscillating current of so-called pure sine wave form, the

current flows in successively opposite directions for the same length of time, and the amplitudes of successive waves bear to each other a constant ratio; that is, so vary that from beginning to end of the oscillations each following amplitude bears the same ratio to the next preceding amplitude. Fig. 14, represents an oscillating current of pure sine wave form consisting of a series of waves of constant length, decreasing in amplitude or strength, in constant proportion."

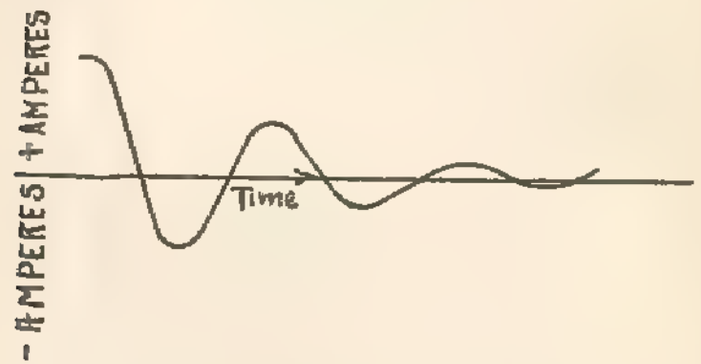


FIG. 14. Illustrating an Oscillatory Impulse.

A current to be designated a high frequency current, must have a high rate of alternation. In a completed cycle each wave crosses the neutral line, completing a double curve from a neutral line across that line and back, making a complete sine wave as of the sinusoidal current which is an alternating current of uniform cycle.

*The term high frequency current* approximately designates a rate of oscillation exceeding 10,000 per second, at which point muscular response or contraction ceases, and run as high as millions per second. An apparatus to produce a current of this character, must derive a current from a source of high potential—a static machine, Ruhmkorff coil or transformer—which is operated in association with a resonator, consisting of condensers in arrangement with solenoids as elsewhere described.



The oldest type of alternating current apparatus was manufactured for therapeutic purposes in 1848 by the Jerome Kidder Co. of New York, as shown in Fig. 15.

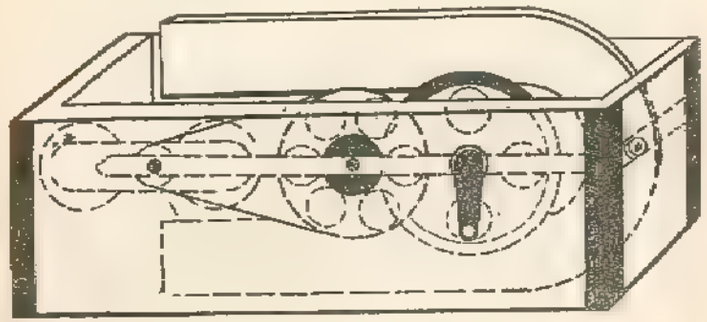

FIG. 15. Jerome Kidder Magneto.

This electro magnetic apparatus, antedated the alternating current dynamo and the sinusoidal machine as later constructed. This type of apparatus may be pointed to as the father of the present type of great generating dynamos. While this apparatus produced a distinctly alternating current, such as the sinusoidal current now produced by the more modern apparatus, the potential was low and the effects painful and disagreeable.

The type of arrangement which first produced currents, that were correctly designated as high frequency currents, was the static induced current as previously described, and first published by Dr. William James Morton of New

York in 1882. The oscillations produced by the spark-gap in the arrangement of this current (See Fig. 4), were the first so recognized oscillatory currents of high frequency.

A modification in the arrangement of this current was made by Prof. d'Arsonval which consisted in connecting the outer coatings of the two Leyden jars with the two ends of a solenoid.

By this arrangement when the current from the two poles of either a static machine, coil or other transformer is caused to pass to the inner side of the two Leyden jars, and when an arrangement with a controllable spark-gap provision is made for interrupting the circuit, oscillations are set up in the solenoid connecting the two outer coats of the Leyden jars or other condensers. Connections tapped off from the two ends of the solenoid or from any of the intervening turns convey a high frequency current of relatively low voltage and high frequency, and a current of a larger amperage or heat producing quality than currents produced by other arrangements (see Fig. 16). By this arrangement it is possible to vary the current strength by increasing the speed of the static machine, or regulating the resistance in the circuit between the street current and the transformer and adjusting by lengthening or shortening the spark-gap. It is also possible by varying the length of the spark-gap and the additional resistance in the circuit, when placing the cushion between the patient and the metal condenser. When the patient—a capacity—is then connected with the other terminal of the solenoid, *the current is converted into a practically unidirectional current of high periodicity* as was clearly set forth in the report of Jenks and Clarke



in the Committee report referred to, pages 83 to 95. The oscillations are damped down by the resistance of the circuit, to the extent that the predominant strength of the current is flowing in one direction, losing to such a large degree its oscillatory character, that the current becomes practically *a unidirectional current of high periodicity.* In other words, a high frequency oscillatory current in which the sine waves of either side of the neutral line are approximately equal is to such an extent damped out that the alternating quality is changed to that of a unidirectional current of high periodicity. In other words a current produced by the same apparatus by varying the resistance or spark-gap, and capacity and the resistance of the couch cushion added to the resistance of the skin of the hands and arms of the patient, his body being the capacity, is converted into a pulsatory current—unidirectional in character—of high periodicity. Definitely stated, a high frequency current is oscillatory and alternating; and a current of high periodicity is pulsatory and unidirectional.

*A distinct type of pulsatory current* is the static wave current, which is also to the greatest extent unidirectional. The current however, from a resonator under the conditions stated, in the preceding paragraph, also becomes practically unidirectional and pulsatory. This may be readily demonstrated by holding in the hands a vacuum tube of fairly high vacuum one end of which is in contact with the body of a patient, seated upon an auto-condensation couch and connected in a d'Arsonval circuit. When contact is made under these conditions with the patient connected to the positive side of a resonator a green fluorescence will immediately appear at the patient's end

of the tube, the cathode stream of negative electrons, passing to the point of contact with the patient's body, results in a production of the x-ray which causes the green fluorescence. Reverse the poles and the fluorescence occurs at the opposite end of the tube.

The differences as to variations of conditions and effects arising from changes in the circuit, require consideration for therapeutic reasons, particularly so if the currents

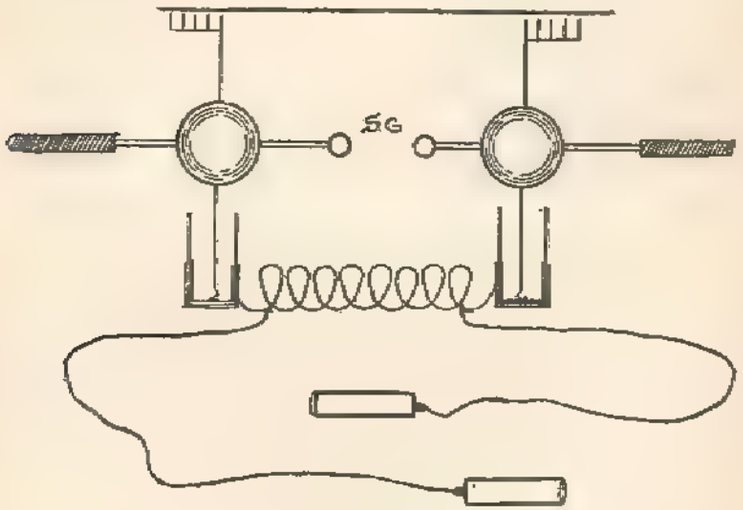

Fig. 16. d'Arsonval Current.

are to be employed conductively for effects upon nutrition and metabolism. These will be considered in a subsequent chapter. When, however, a current is employed for the induction of hyperemia, either by means of the thermic effects of the current, or by the superficial stimulating effects of the discharges from the effleuves or vacuum tubes to the skin, it will be relatively alternating,



though not to the same degree as the d'Arsonval administration by the direct method when the current passes directly through the tissues of the patient without other resistance.

*Confusion is apt to exist* in the mind of the student as to the relative quality and indications for the employment of the various high frequency modalities, particularly of

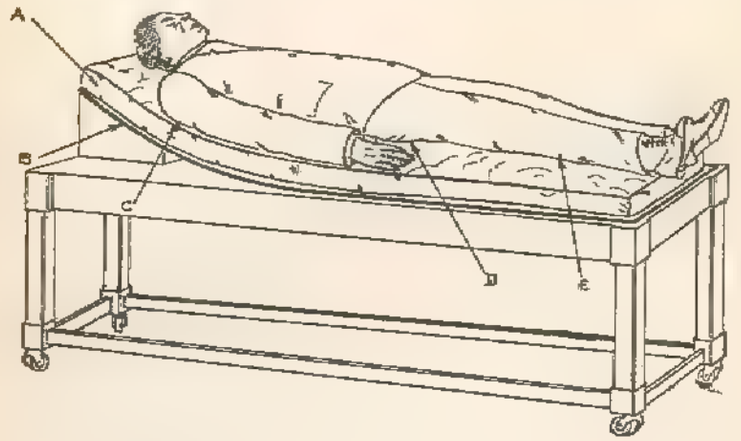


Fig. 17. Arrangement for Auto-Condensation.
A, Dialectric; B, Metal Plate; C, D, E, Points of greatest Condensation.

the d'Arsonval, Tesla and Oudin currents. It seems that those who are not informed are liable to consider these currents much as they do certain drugs of the pharmacopoeia; as producing distinctly different therapeutic effects, and possessed of distinctly different qualities of action, which is generally not so. Variations in current strength or amperage and potential or voltage, together with the characteristics of the current as to frequency or

periodicity, are the differences generally to be considered in treating with these modalities.

*The static induced current*, the first of the high frequency currents, is considered in Chapter III, Section II of this work (q. v.).

*The d'Arsonval current*, Fig. 16, produced under the peculiar conditions of arrangement as shown in the cut, is the current of largest amperage and lowest potential of the high frequency currents. It has, consequently, the

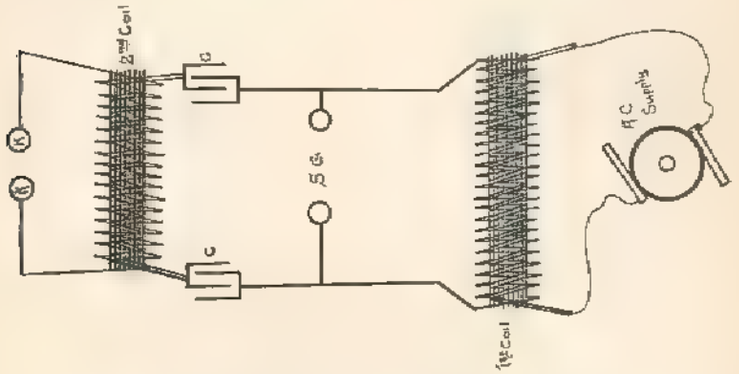


Fig. 18. Arrangement for Tesla Current.

greatest capacity to induce heat in its passage through the tissues, and at the same time produces a minimum of other disturbing effects. It is administered to the patient either upon the auto-condensation couch (Fig. 17), or within the solenoid by the method of auto-conduction (Fig. 45).

*The Tesla current* is a current stepped up from the d'Arsonval; i. e., a current in which the voltage has been raised by passing it through a second solenoid at the expense of the amperage. It comprises a completely insu-



lated and unconnected solenoid, either within or surrounding a d'Arsonval solenoid (see Fig. 18). The resulting current as stated is reduced in amperage and the voltage is increased. The variations in voltage are measured by the difference in the length of spark or effleuve, the potential of delivery, which will pass to a capacity when brought into the field of the discharge as compared with the length

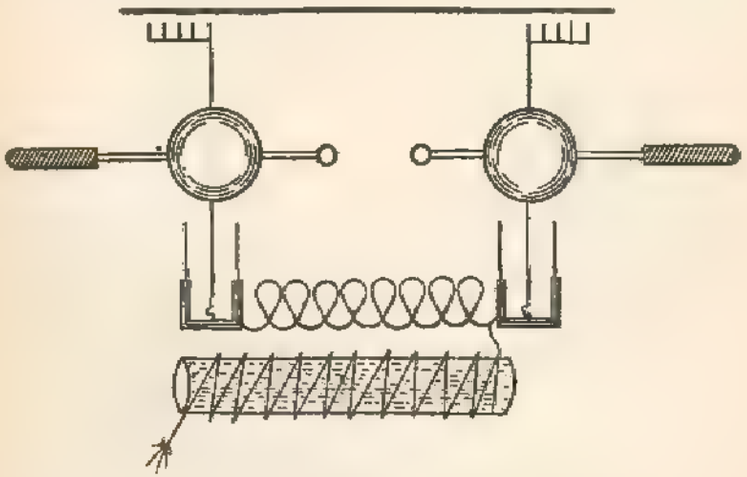

Fig. 19. Arrangement for Oudin Current.

of the discharge from the d'Arsonval circuit. This current, like the d'Arsonval current, is administered from two terminals, or from one terminal when from a static machine with the other terminal of the resonator grounded, when the discharges are more penetrating and stimulating in character. The effect of grounding one side of the Tesla is very different when the apparatus—the resonator—is in connection with a Holtz machine than with the Ruhmkorff coil or other transformer. The current

from the static machine is rendered very similar in effect to the Oudin current from the same source, when one side of the Tesla is grounded.

*The Oudin current* is produced with a solenoid connected to one end of a Tesla or d'Arsonval solenoid, and operated with an electrode attached to the solenoid; and the current is properly speaking a one pole current, the circuit being completed through the body of the patient, which acting as a capacity, stores and conducts the opposite polarity to the discharging electrode. The current may be varied in the quality of the oscillations under varying conditions of regulation of the spark-gap and control of the current which passes into the resonator, and the character of the grounding (see Fig. 19).

When employed in connection with the static machine the Oudin, as with the Tesla current, discharges a pulsatory current the pulses of which are synchronous with the discharges from the Leyden jar at the spark-gap with a more positive and marked effect than when discharged from the solenoid connected with a coil or transformer.

*These modalities* will be treated in separate chapters but are here considered for the purpose of showing the differences as to the quality and character of the current produced.

*The variations in quality* of the currents of high frequency and high periodicity must be considered from the standpoint of the physical effects produced which depend upon the method of administration and the variations in current strength and potential employed. It should be understood, that the current strength and potential can be varied with any of these modalities, either by varying the spark-gap in the resonator, or the speed of the static



machine, or the amount of current allowed to pass into the primary of the Rhumkorff coil or other transformer.

It will then be understood that the variations in the matter of current strength and potential is under control of the operator; and that under these conditions a current may be produced in a d'Arsonval circuit which under different conditions would simulate a current from a Tesla transformer. Also that a current administered from a Tesla or d'Arsonval from one pole might be varied to produce a similar effect if it is discharged from an Oudin under varied conditions. It is necessary then to study the effects of these currents, from the point of view of the amount of current and potential acting upon the tissues; whether the d'Arsonval, Tesla, or Oudin is employed; for the character of effect which is induced under varying conditions from either of these modalities may be much the same, with no particular advantage in either case, except when extremes indicate a greater or less effect to be produced. *The effects that are produced* with currents of high periodicity or high frequency are (1) *tonic effects,* or effects upon general metabolism and nutrition; (2) *hyperemic effects,* superficial hyperemia being induced by vacuum tubes, or deep hyperemia by the thermic effects of passing a high frequency current of considerable amperage between two electrodes placed upon the body at opposite surfaces, when the d'Arsonval by the direct method is the current to be preferred; because with a similar potential and larger amperage as well as being a more convenient method of administration, the current is more satisfactorily produced. Other effects are (3) *local skin stimulation,* and (4) an extreme cauterant or destructive action as produced by the method of Riviere

first called effluvation, designated by Kaeting Hart under the name fulguration.

For the induction of these effects, either of the currents may be chosen, preferably the d'Arsonval or Oudin currents which meet all requirements. The currents of the so-called "Tesla transformers" meet the last two indications.

The methods of application and specific indications will be specifically considered in the chapters devoted to each of the modalities.

## CHAPTER II

### APPARATUS

THE different types of apparatus now in use for the production of currents of high potential of high frequency and high periodicity are the Ruhmkorff coil (open magnetic circuit transformer) apparatus, closed magnetic transformer with condenser or motor converter, the three types of static machines, Holtz, Toepler Holtz and Wimshurst, and the so-called Tesla apparatus.

*The Ruhmkorff coil*, Fig. 36. In comparing the different types of Ruhmkorff coil, we have to consider both the method of winding the primary and the construction of the secondary. In all of this type of apparatus a large bundle of soft iron or sheets of soft iron constitutes the core over which is wound the primary coil. The primary winding may be of (1) the series, (2) the multiple series, (3) the parallel or (4) variable inductance construction.

*In the series* there is a continuous winding of one, two, three or four layers of heavy copper wire in series.

*In the multiple series* the windings are arranged in such a manner that there are four or more sections connected in such a way that part of the current passes through two of the sections, while the remainder passes through the remaining two sections.

*The parallel* consists of two sections of primary winding, in which a part of the current passes through each section.

*The variable inductance primary* consists of a long continuous winding, tapped out at different points in such a manner that the current will pass through as many sections as are brought into the circuit by the variable inductance switch. Any one of these primaries can be used in connection with any of the different types of secondary.

*The secondary of the Rhumkorff transformer* or coil, may be wound in the bobbin form, which consists of two long sections of fine wire passed over the primary in such a position as to be brought into the strongest field of the magnetic flux set up in the primary.

*Another method of winding* is the so-called wide section secondary which consists of winding 1¼ inch across each layer, and each layer separated by rings of paper. A set of these are placed over the primary, and connected in series, and then either immersed in oil or semi-solid insulation. The third type which is by far the most efficient, is the thin section construction which consists of flat discs of ¼ inch connected in series, and placed over the primary in such a position as to receive the strongest magnetic flux from the entire length of the primary. In order to accomplish this and reduce the resistance in the secondary winding, the end is wound much shorter than those in the central portion.

A very important feature in the construction of these coils is the character of insulation employed particularly the insulation over the primary core, between it and the secondary. The best evidence of the quality of construction of these coils is the character of guarantee which the manufacturer is willing to give as to the endurance of the apparatus.

In order to excite the Rhumkorff coil, it is necessary to



use some form of interrupter, and the ordinary equipment consists of the coil, interrupter, rheostat, ammeter for measuring the circuit which passes from the street circuit into the primary, and in addition for therapeutic uses, the proper types of resonator and a hot wire milliamperemeter.

*The different types of interrupters* now in use are (1)

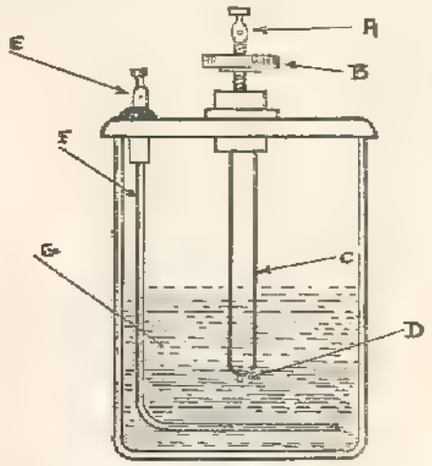


FIG. 20. Wehnelt Interrupter.
A, Positive Connection to Line; B, Adjusting Screw; C, Porcelain Tube; D, Platinum Point; E, Negative Connection to Line; F, Lead Plate or Spiral; G, Electrolyte $H_2SO_4$ and $H_2O$ or Mg. $S_4$ and $H_2O$.

the electrolytic, (2) mechanical, (3) mercury jet, and (4) the centrifugal.

There are two types of electrolytic interrupter; namely, the Wehnelt (Fig. 20), and the Caldwell; the former depending upon the formation and the breaking of a bubble of gas around the platinum point, immersed in some form of electrolyte, as diluted sulphuric acid, which is of high electric conductivity. The Caldwell (Fig. 21) in-

terrupter depends upon forcing the bubbles of gas through an aperture in a diaphragm, having an electrolyte and electrode on either side, each electrode being connected to the two opposite poles of the exciting current in series with the coil or transformer.

The disadvantage of this type of interrupter for use in

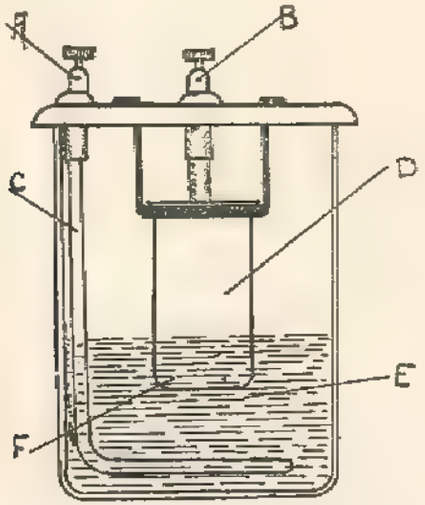


FIG. 21. Caldwell Interrupter.

A and B, Positive or Negative Terminals; C, Lead Plate or Spiral; D, Porcelain Beaker; E, Electrolyte; F, Aperture Through Beaker (One or More).

connection with d'Arsonvalization and other high potential currents is the fact that when used continuously or for long treatments the fluid becomes heated, and must be rested, except very large tanks are employed, or a series of interrupters. Another objection is that the irritating hydrogen gases evolved in the process of interruption escape into the atmosphere of the room, thereby vitiating



the air, as evidenced by a constant disposition of those in the room to cough.

*There are several types of mercury jet interrupters* all of which depend upon a fine stream of mercury projected against a conductor at intervals, the conductor being con-

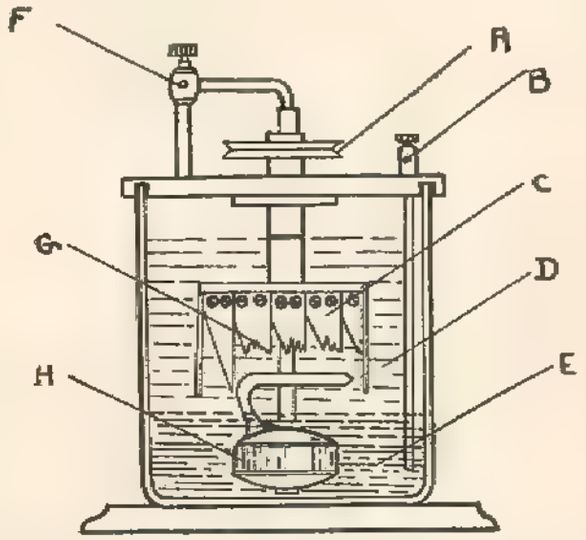


FIG. 22. Mercury Jet Interrupter.

A, Pulley to be Driven by Motor; B, Terminal Connecting with Mercury; C, Insulated Revolving Contacts; D, Oil; E, Mercury; F, Terminal Connecting with Revolving Contacts; G, Segments Cut Away to Show Jet Tube; H, Mercury Pump.

nected in series with the coil and part of the apparatus which delivers the stream of mercury. The objection to these interrupters is a constant disposition of the mercury to become oxidized by the current, requiring frequent cleaning if much used. This may be overcome by passing illuminating gas into the chamber with the mercury.

The centrifugal interrupter (Fig. 23) consists of a

revolving conductor so formed that the mercury is forced into a groove in the periphery of the container, in which a paddle or bar of metal is mounted eccentric to the shaft of the container, and an insulated external connection brought to one side of the line while the container itself is connected through the primary of the transformer, and

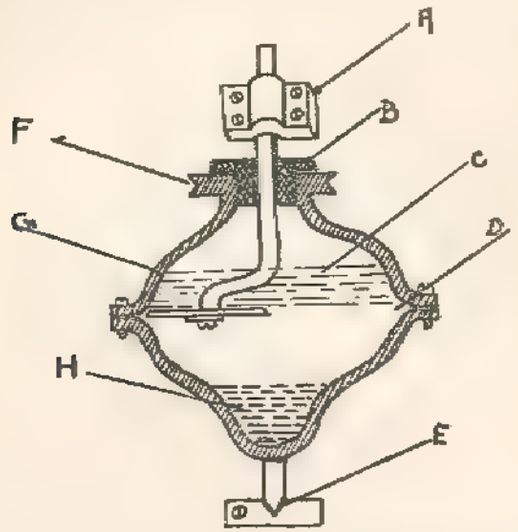


Fig. 23. Centrifugal Interrupter.
A, Connection to Revolving Contact; B, Insulating Bushing; C, Oil; D, Groove for Mercury; E, Lower Bearing; F, Grooved Pulley for Belt to Motor; G, Chamber Made to Revolve; H, Mercury.

thus to the opposite side of the lines. As the body of the interrupter is revolved, the mercury is forced into a groove which also causes the paddle to revolve, thereby setting up interruptions in the circuit.

The same objection—the oxidation of mercury—prevails with this interrupter as with the mercury jet-interrupter.

*The mechanical interrupter* (Fig. 24), the choice of in-



terrupters for therapeutic purposes, may have for its point of break two small surfaces of platinum or as in the later types the platinum points as used are usually operated by an auxiliary make and break, or originally the contact was actuated on the well known vibration principle as in the primitive "Faradic battery." These latter were called vibrators and to-day are quite satisfactory in small batteries and in so-called high tension coils, with which low volt currents are to be used for certain classes of treat-

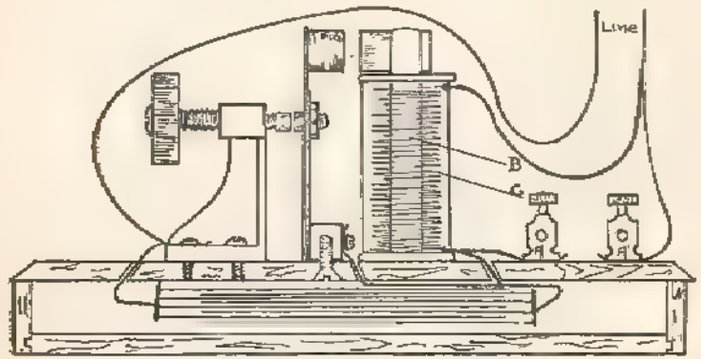


Fig. 24. Mechanical Interrupter.
A, Connections for Primary of Coil; B, Magnet Winding; C, Magnet Core.

ment. There is one great advantage in all of the so-called mechanical interrupters, namely, they require very little attention and do not have to be frequently cleaned and re-charged. They are particularly valuable in connection with the therapeutic employment of high potential currents as they may be used constantly without becoming overheated or requiring any attention whatever, except oiling the bearings. The scope of the mechanical interrupters having the motor and wide contact, however, is much broader than the early types of interrupter, in that

the larger currents can be used and very satisfactory results obtained with both the x-ray tube and the d'Arsonval and Oudin currents. The only attention which these require is an occasional oiling of the motor and other moving parts together with the proper adjustment of the interrupter to the work in hand.

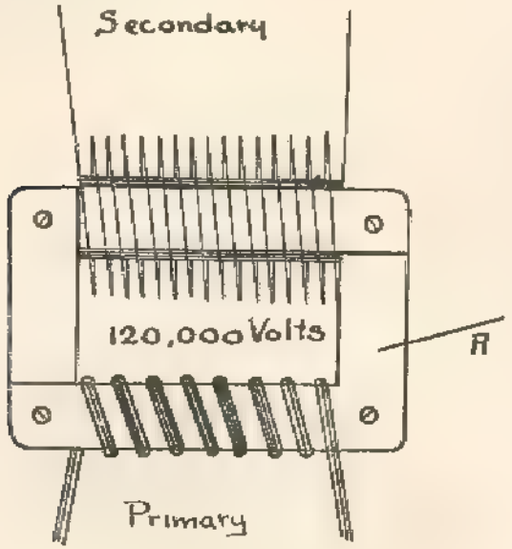


Fig. 25. Closed Magnetic Circuit Transformer.

*The closed magnetic circuit transformer*—interrupterless transformers—(Fig. 25), consists of a soft iron core so constructed that the magnetic flux can follow a course of low magnetic resistance. In order to accomplish this the core is constructed of laminations or layers of soft iron which form a rectangle or square with the corners built up in such a manner as to approach complete molecular or metal continuity as nearly as possible.



In transforming the commercial current, engineering calculations can readily be made to produce any desired potential in the secondary from a given voltage in the primary where the construction of the core is such that magnetic leakage and resistance are reduced to a minimum. Therefore the magnetic circuit must be as short

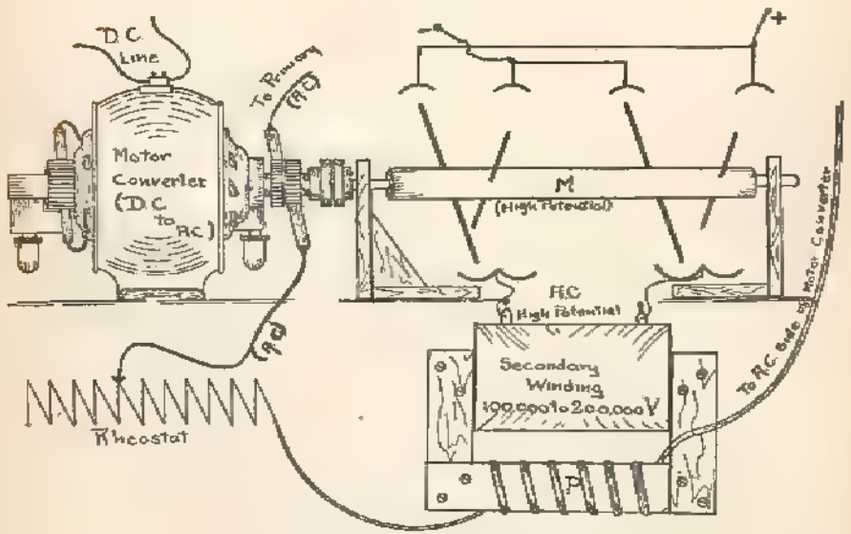


Fig. 26. High Potential Rotary Rectifier.

as possible and the magnetic leakage low, to assure accuracy in calculation. This method of generating high potential currents for both x-ray and high potential therapeutic purposes, produces most satisfactory results as a much longer range of effects can be produced, and at the same time a much larger output. There has been difficulty however in constructing this type of apparatus,

owing to the fact that it is difficult to properly insulate the secondary and at the same time produce sufficient voltage for the purpose intended. This, however, has been to a great extent overcome, and transformers are now being constructed which meet the requirements admirably.

The introduction of this powerful machine has had the effect of revolutionizing radiography. It is no longer difficult to make a radiogram of any part of the body in an instant of time.

There are three types of apparatus entirely different in their construction, in which the closed circuit type of transformer is used,—(1) *the high potential rotary rectifier* or so-called interrupterless, (2) the Tesla, and (3) the condenser and alternating type, called the McCaa transformer.

*The high potential rotary rectifier and interrupterless transformer* is operated by an alternating current generated from a motor-converter—a rotary transformer—with an extension of the shaft of the motor-converter operating a high potential pole changing switch (Fig. 26). This switch is set in such a position as to catch the peak of the alternating wave from the secondary, in such a manner as to bring the positive impulses to one discharge post and the negative impulses to the other.

In this manner a unidirectional current is produced, and all inverses are avoided. The apparatus is particularly valuable on that account for radiography and radiotherapy, and adaptable as all other transformers are when used in connection with the proper resonator, for the induction of high potential therapeutic currents, thereby combining in one apparatus the best type of x-ray apparatus with an apparatus in every way capable for the



induction of currents of high frequency and high periodicity.

*The condenser and alternating type* called the McCaa transformer equipment, consists of an alternator driven by a small motor, and connected in series with a large condenser primary of the transformer and the line current (Fig 27). Oscillations are thus set up in the primary from the discharging of the condenser, which

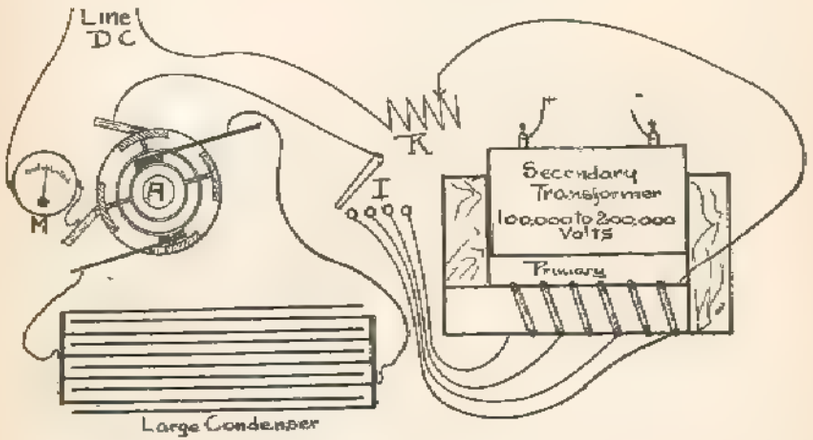


Fig. 27. McCaa Transformer.
A, Alternator; I, Inductance Switch; R, Rheostat; M, Meter.

cause by induction the high potential discharge at the secondary terminals. With this construction either an alternating or pulsating high potential current can be generated at the will of the operator. The number of these oscillations can be varied from 60 to 800 per second, and can be used through an x-ray tube or high frequency resonator.

*Mixed types of high frequency apparatus* have been placed upon the market by different manufacturers, which have various arrangements for administering different degrees of potential, amperage and frequency under modifications produced by varying the condenser capacity, spark-gap, and their arrangement with solenoids or coils in circuit with the patient. Most of these devices are made for use with the alternating current. When the direct current is used, a rotary transformer is provided in the circuit for changing to the alternating current. These combination coils are generally so constructed as to vary the current from the sharp stinging discharges of the Tesla, to the softer heating effects as of the d'Arsonval current. With these devices it is possible often to be very much misled by the variations produced in readings of the hot wire meter in circuit; for in these various current conditions that are produced, the hot wire meter is not an accurate guide as to the current amperage, because increasing the frequency of the discharges increases the readings without increase of amperage. The test as stated elsewhere, of the efficiency, will be the extent to which the usual seance will lower arterial tension in cases of hypertension. For the induction of hyperemia the current strength will be as in all cases regulated to the toleration of the patient and the indication for a case in question.

*The Tesla apparatus,* so-called, consists of a comparatively low voltage rotary converter, for changing the current from direct to alternating, connected in series with the primary of an oscillation transformer and a comparatively low capacity condenser. This apparatus delivers a high frequency alternating current of relatively low amperage and must be used in connection with a valve tube



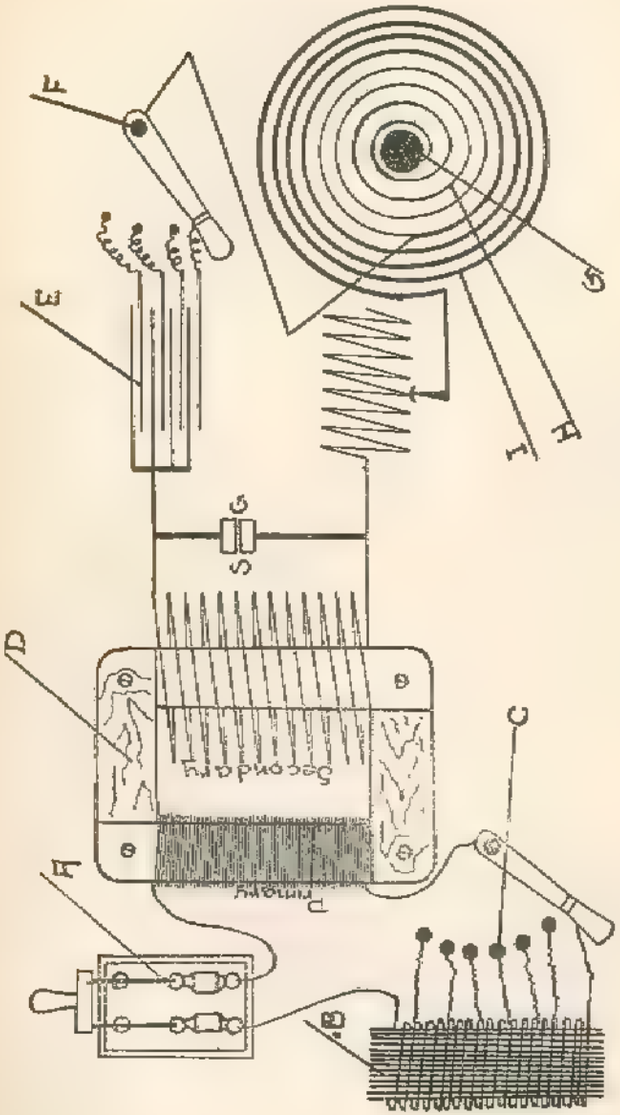


FIG. 23. So-Called Tesla Coil.

A, Supply; B, Iron Core; C, Inductive Rheostat; D, Transformer Constructed for Different Voltages from 500 to 2,000; E, Variable Condenser; F, Condenser Switch; G, Terminal for Tesla Brush Discharge; H, Secondary of Oscillation Transformer; I, Primary of Oscillation Transformer; S G, Spark-gap.

or bifocal x-ray tube for producing the Roentgen ray. The above described construction is called the Tesla coil. The method however, in which Mr. Tesla constructed his equipment was somewhat different in that much higher initial frequencies could be taken into the primary of the transformer and he also used a transformer which delivered a much higher voltage than the apparatus made to-day, besides building the oscillation transformer in a different way. (Fig. 18.)

*Other types of so-called Tesla coils* are being manufactured of various features of construction, and are called Tesla apparatus. These coils step up the voltage and produce currents alternating in character which while not true Tesla currents, are capable of producing some of the therapeutic effects of the high potential currents. Fig. 28 represents the arrangement in one of this type of apparatus.

These devices are not adaptable to use for administering auto-condensation or auto-conduction, but suffice well to meet other indications for high frequency treatment; viz.: the stimulating effects of the vacuum tube discharges and effluvation or fulguration. It is a very convenient portable x-ray outfit combining means for applying the high frequency referred to. Manufacturers in general have used the term Tesla current for nearly every type of construction from the resonator excited by a coil to the resonator operated by a static machine; but this is generally erroneous; in that the resonator ordinarily used in connection with the various coils and static machines delivers frequencies of moderate rates while the oscillations from the small Tesla apparatus which is made up in portable and semi-portable form delivers frequencies



approximately fifty times as great per second, which consequently represents a very different type of current. In

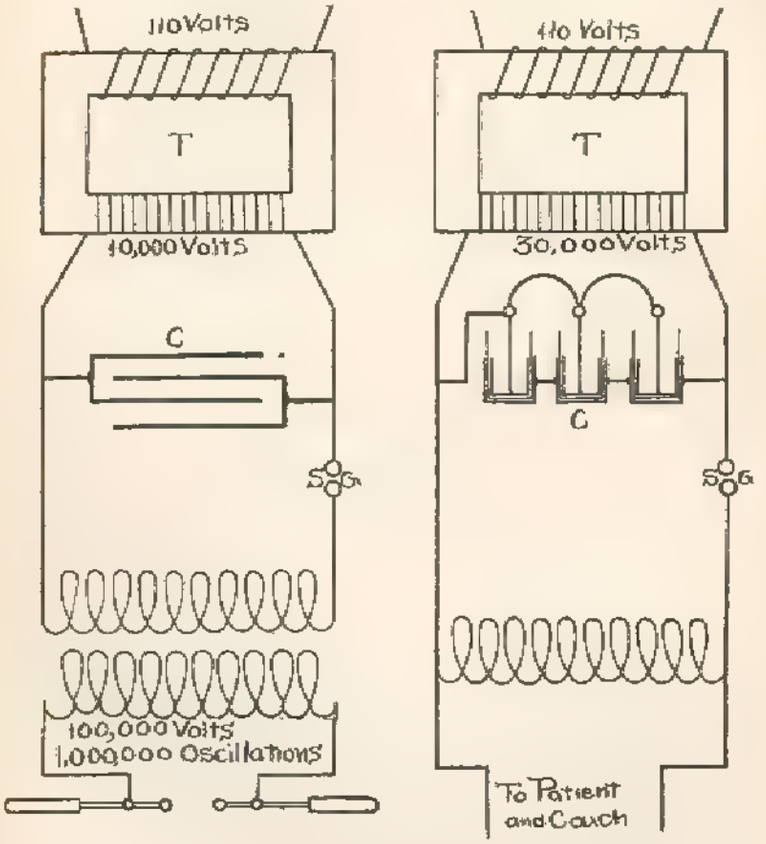


FIG. 29. So-called Tesla Types for Administering Auto-Condensation and Other Treatment.

fact if it were not for these very rapid oscillations in the condenser, the effectiveness of the so-called Tesla apparatus would be very low.

*The particular advantage* of the Tesla over the other types for use, is in cases in which small currents are necessary and the alternating current alone at the disposal of the operator. The portability of the apparatus also renders it possible to employ it at the houses of patients in which either of the commercial currents is furnished.

There has recently been placed upon the market other new types of transformer apparatus for treatment work only, where the alternating current can be used directly into the primary without the interception of a rectifier, interrupter, or synchronizer (Fig. 29).

This apparatus consists of a closed magnetic circuit transformer capable of delivering a two to three inch discharge, the secondary being connected to Leyden jars and a resonator in circuit constructed along the lines of the ordinary Oudin. The d'Arsonval current is taken from the end of the spiral and the point which taps out the different turns, precisely as is done when the coil or static machine generates the initial high potential current.

*Apparatus for use with the alternating current:* The alternating current is so rapidly displacing the direct current in commercial circuits, that new problems are constantly arising for solution, particularly with the physicians who employ to far greater advantage the direct current for apparatus operated by motors, and Ruhmkorff coils and wall plates; and many others are placed at a great disadvantage when power companies change the current from direct to alternating. The static machine to be successfully operated requires a means of speed control whereby the volume of current flowing into the motor can be regulated for which purpose the direct current resistance controller is the best method for speed control. *The mechanical speed controller* is the best substitute but not so well adapted for the employment of high speed in connection with the production of the static current.



This subject has also handicapped, in many instances, the manufacturers of apparatus, in that the direct current has been most generally in demand by the profession, and

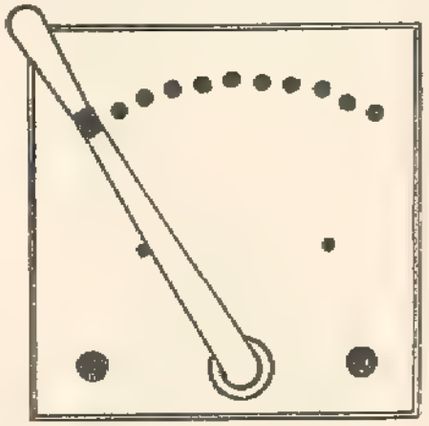

FIG. 30. Rheostat.

that, now the apparatus under process of construction are often of the direct current type.

*Various means of current transformation* have been devised for the purpose of rectifying or changing the alternating into the direct current, including (1) the motor dynamo, (2) the Cooper Hewitt rectifier and (3) the electrolytic rectifier. Any device that can succeed in this form of transformer will be most acceptable to the medical profession and to the manufacturers of apparatus.

*The motor dynamo,* though expensive is the most practical means of current transformation. It consists of an alternating current motor (Fig. 32), which actuates a direct current dynamo, and is constructed in the most

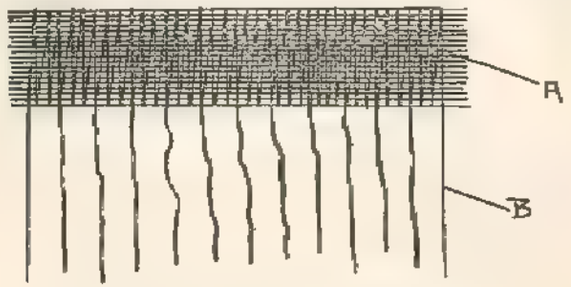


Fig. 31. Inductive Rheostat.
A, Iron Core; B, Terminal of Winding.

economical type upon a continuous shaft. A physician's outfit comprising a motor-dynamo of ten to fifteen amperes capacity or less for smaller plants, is capable of trans-

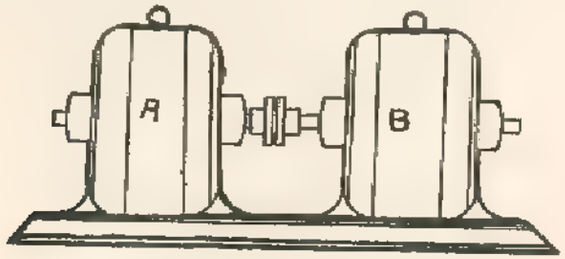


Fig. 32. Motor Generator.
A, A. C. Motor; B, D. C. Generator.

forming a current for use with the direct current, Ruhmkorff coil with the motors used for operating static machines and vibrators as well as for connection with the wall plate. This is undoubtedly the most practical type



of transformer, but adds an expense of $200 to $600 to the physician's outfit, which is to be considered only as an element of first cost, as the apparatus will last for an indefinite time with ordinary precautions as to oiling and care in not making excessive demands on the generator. The apparatus is also economical in principle as

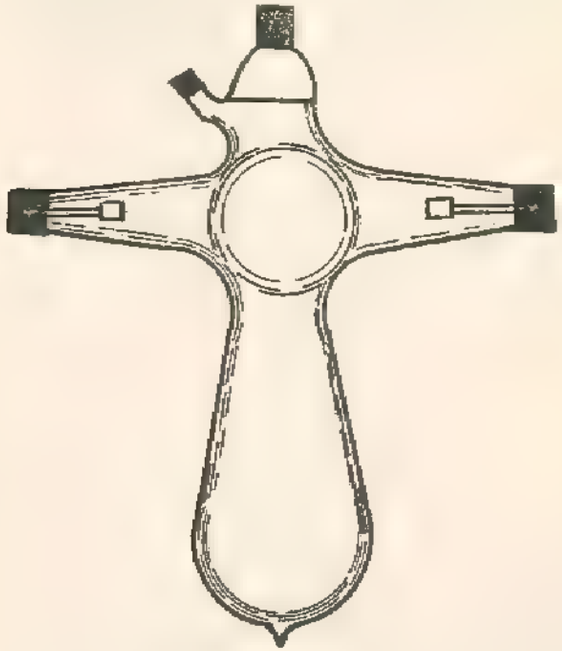

Fig. 33. Cooper Hewitt Rectifier.

the current drawn for consumption will regulate the current taken from the commercial circuit for exciting the actuating motor. The current generated and power consumed is relative to the demand—the speed and actuating capacity increasing up to the full demand of the direct current generator to actuate current.

*The Cooper Hewitt rectifier,* Fig. 33, is probably the next best means of transformation. It has however, the disadvantage of necessitating a continuous flow of current through the bulb whether it is being used into the primary of a transformer or not, during the short intervals in which the operator is obliged to shut off his current from the apparatus. It has the advantage however, of giving a continuous flow of unidirectional current up to its full capacity and is very satisfactory for charging

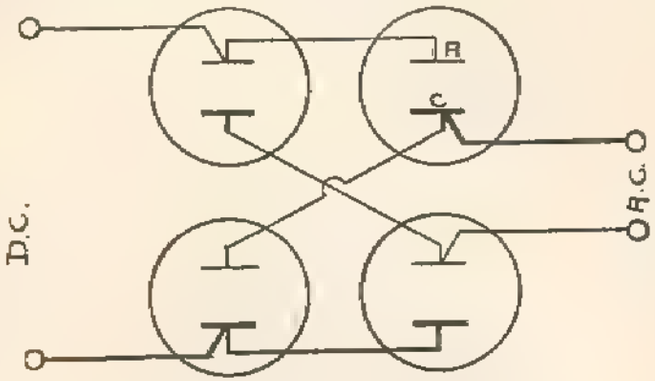


Fig. 34. Electrolytic Rectifier.
A, Aluminum Plate; C, Lead or Carbon Plate.

storage batteries, which requires a direct current; for in this case some means can be employed to shut off the current when the apparatus is temporarily disconnected.

*The electrolytic rectifier,* Fig. 34, consists of aluminum and lead or carbon electrodes immersed in a saturated solution of bi-carbonate of soda, sulphate of magnesium, sodium, potassium, or ammonium phosphate. For the best results four cells are used and connected in such a way that the positive current can be taken from one side



and the negative from the other and have both sides of the line effective. For some purposes a one-cell rectifier is used, in which case one side of the line is suppressed, while the other delivers a unidirectional current up to forty or fifty volts, but is not suitable for operating motors or galvanic or Faradic switchboards or under conditions when a continuous current is necessary. The action of this instrument or apparatus depends upon the rapid formation of an aluminum compound on the aluminum plate when the current is passing from the iron or carbon toward the aluminum, the compound offering a very high resistance and for the time checking the current from making a complete circuit. At the interval when the current is passing from the aluminum to the carbon this film of aluminum compound no longer retains its insulating quality and allows the current to pass. It can be readily seen that the combination of four of these can be so connected that each cycle from the line can be taken advantage of. The most desirable compound to use due to its cheapness especially, is bi-carbonate of soda in the proportion of one part of bi-carbonate of soda to twelve parts of water, both by measure. It has also the important advantage of not crystalizing and in forming insoluble compounds which partially reduce the capacity of the outfit by clinging to the metallic parts.

*The high frequency resonator.* The apparatus commercially known as the high frequency resonator can be operated from the Ruhmkorff coil, the high potential rotary rectifier (so-called interrupterless apparatus), the McCaa transformer equipment or the static machine and is constructed on practically the same plan for all these types of apparatus. The length and size of the d'Arsonval

solenoid for the Rhumkorff and other types of transformer require from six to fifteen turns from eight to twelve inches in diameter of coarse wire, while the d'Arsonval solenoid for the static machine should be of coarse wire having from thirty-five to forty turns in the solenoid wound from four to six inches in diameter. Another part which necessitates

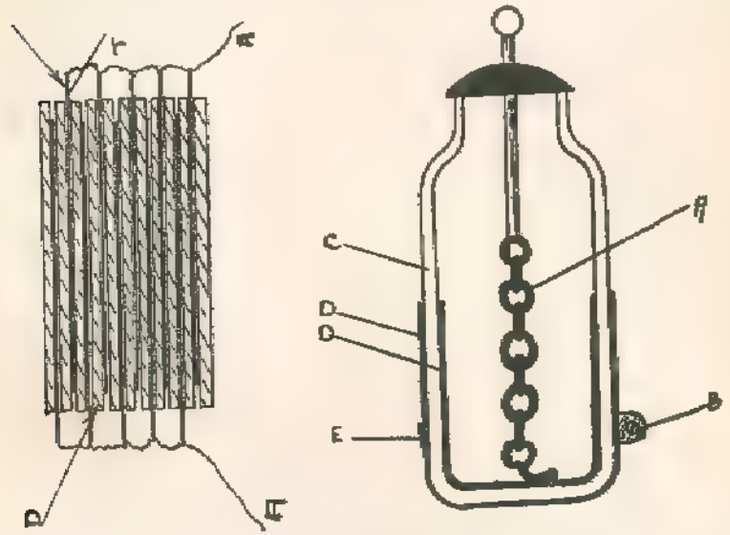


Fig. 35. Types of Condensers: Leyden Jar and Glass Plate.
Leyden Jar: A, Conductor for Inner Armature or Layer of Foil; B, Connection for Outer Armature; C, Dielectric; D, Tinfoil or Copper Plate; E, Band Around Jar for Outer Connection. Glass Plate: A, Terminal; D, Dielectric; T, Plates of Tinfoil or Select Metal.

variations, is the capacity of the condensers, which is a very simple matter. The condenser capacity in the type of static resonator constructed to produce the pulsatory Oudin or Tesla discharges should be of approximately three times the capacity as measured by the extent of the surface coating of metal on the outer and inner surfaces



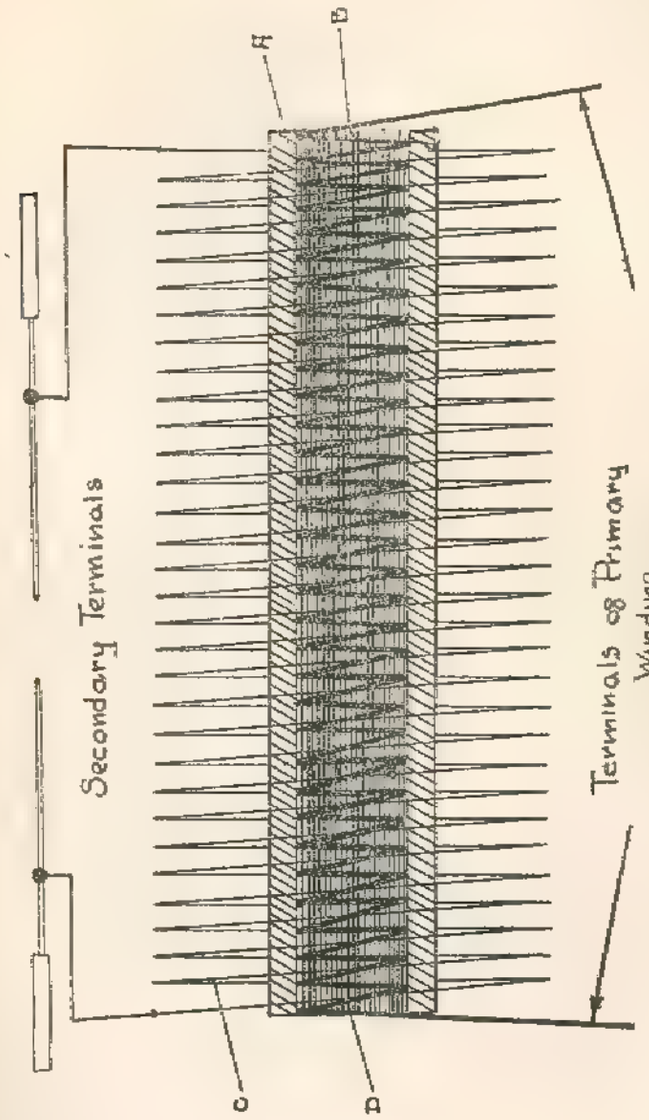


Fig. 36. Winding of Rhumkorff Coil.
A, Rubber or Micanite Tube; B, Soft Iron Core; C, Secondary Winding; D, Primary Winding.

of the Leyden jars or glass plate type of condensers used in connection with the same apparatus for inducing d'Arsonval current as employed for the auto-condensation or auto-conduction.

*The essential parts of a resonator consist of a solenoid, condenser, and the spark-gap* over which may be placed a second solenoid and insulated for the induction of the Tesla current and an additional solenoid for connection with the Tesla or d'Arsonval for stepping up to the Oudin current. (See Figs. 16 and 18.) Although there are two ways of winding a solenoid, it really consists of numerous turns of wire, as previously described, the turns separated by at least ⅜ inch, one end terminating in a binding post from which is taken the Oudin current, Fig. 19. The other end of the resonator is attached to the outer coating of the condenser while the outer coating of the other condenser terminates in a clamp, which makes it possible to tap out any number of turns desirable for varying the d'Arsonval circuit. The inner coatings of the jars are in direct metallic connection with the coil or static machine while at some convenient point in the circuit is placed the spark-gap or discharger, which has the effect of charging and discharging the Leyden jars when the apparatus is in action. When it is required to operate the apparatus the variable tap connection is attached to one of the turns of the solenoid which will produce the best resonance and effleuve at the Oudin end of the solenoid. When however it is desired to use the d'Arsonval current connection is made from one end of the solenoid to the metal strip under the cushion of the auto-condensation pad and the other is brought out from the point which governs the number of turns. This is connected to the



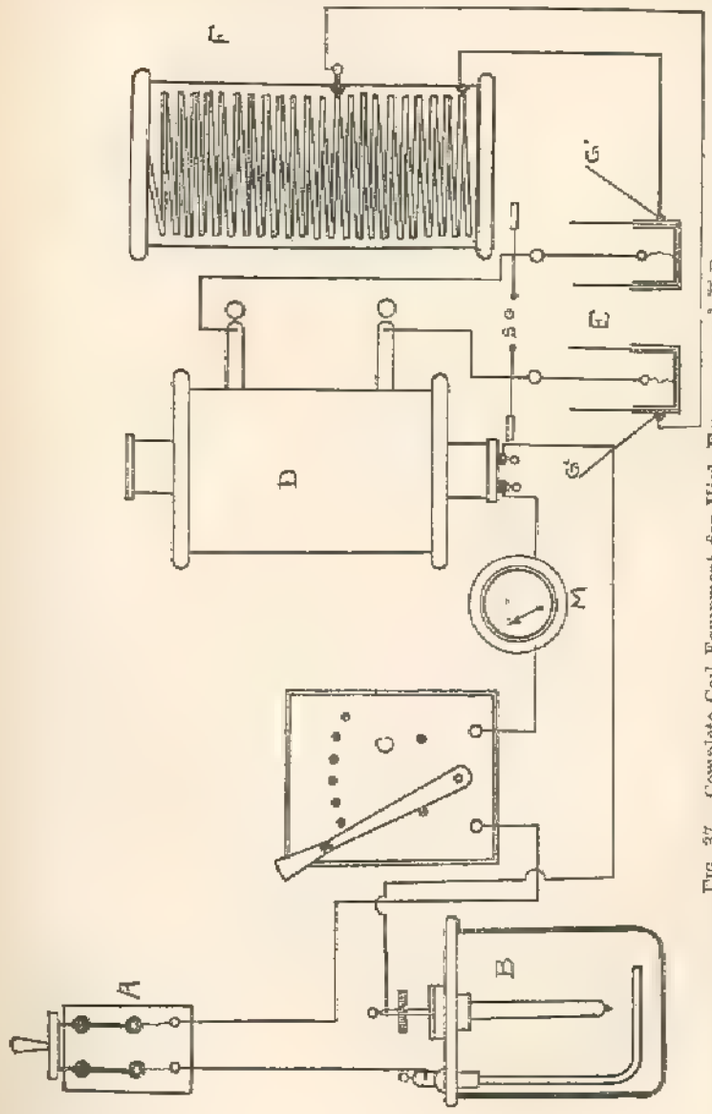


FIG. 37 Complete Coil Equipment for High Frequency and X-Ray.
A, Line switch; B, Interrupter; C, Rheostat; D, Rhumkorff Coil; E, Leyden Jar Condensers; F, High Frequency Solenoid; G1 and G2, d'Arsonval Terminals; SG, High Frequency Spark-gap; M, Meter.

bifurcated cords with the electrodes to be held in the hands of the patient at the two extremities. There have been several deviations from this construction, but the above describes the resonator in its most simple and satisfactory form.

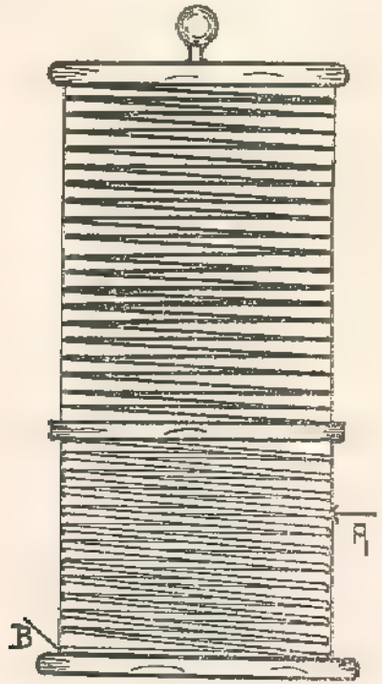


FIG. 38. The Step-up Solenoid.
A, Selective Rheostat; B, Winding of Resonator.

An important feature in the construction of a resonator is the size of the box or *detonating chamber* in which the spark discharges. The tendency for moisture to constantly accumulate in this chamber often interferes with the production of the required milliamperage by the occurrence



of short circuits due to dampness in the walls of the muffler or detonating chamber. It should have therefore, at least a capacity of 1,500 cubic inches with a door on one side which can be opened, for ventilation when not in use, and may be provided with some drying material for absorbing the moisture. This is one of the most important features to be considered in the construction of a resonator.

## CHAPTER III

### D'ARSONVALIZATION

THE current of d'Arsonval which is destined to play such an important role in therapeutics, was first published by Prof. d'Arsonval in the year 1893. Subsequently he developed methods of employing the current in connection with couches and solenoids under the terms *auto-condensation* and *auto-conduction*. These methods have been materially varied since their introduction by d'Arsonval; but the principles of action and their effects were well studied by him. The profession however have been slow in appreciating the significance of these modalities and adopting them in the treatment of numerous conditions for which they are so remarkably adapted; notably in conditions of high arterial tension, mal-nutrition and malassimilation, and more recently the employment of the *direct-method* for its thermic effects for the induction of hyperemia and other effects. These have placed humanity under a lasting obligation to the great physiologist.

*The method known as auto-condensation* (see Fig. 17), would seem in its designation to be a misnomer; for the current is passed in and out of the patient who becomes passively, not actively, a condenser. If the term body condensation or patient condensation were to be employed, it would better explain the conditions. The term *thermic* condensation has been suggested, because of the heat produced by this method. This title also has the dis-





advantage of not being distinctive, heat being induced in numerous other ways.

The devices used in connection with auto-condensation treatment to be considered are the couch, the condenser, the cushion and the electrodes.

It matters little what is used for the *auto-condensation couch*. It may often be thought that the couch should be of a non-conducting material, which is not necessary,

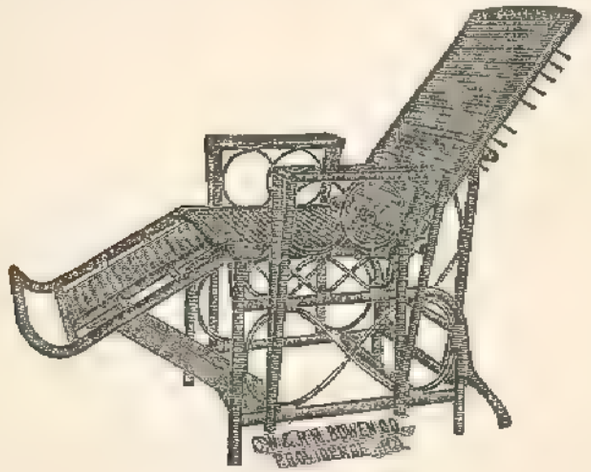

FIG. 39. Bowen Static Chair Designed by Author.

because the two opposite charges of the d'Arsonval current are certain to occupy fields of condensation as near as possible to each other. Two styles of couches shown in Figs. 39 and 40, are excellent for use with this method of treatment, because the patient rests relaxed in a comfortable attitude with the limbs extended, which is desirable. A table or ordinary lounge in lieu of a chair will answer every purpose of efficiency for the administration of auto-condensation treatment.

*The cushion* should be approximately three inches in thickness, six feet long and twenty inches wide and may be made of any non-conducting material, cotton, felt, or silk waste, answering the purpose equally well. The cushion should be firmly tied and of a material that will not too readily pack together, because wherever the cushion is thinnest, most of the current must accumulate.

FIG. 46. Austrian Bentwood Chair.

The covering of the cushion may be of denim, silk or leather or other non-conducting material. Patent leather imitations, which contain mineral paints, are objectionable as they are too good conductors of the current.

*The metal condenser* which may be made of wire mesh or metal plates jointed or otherwise, should be of a size that will lay about three inches within the margin of the cushion on all sides. A very convenient way of arranging



the condenser sheet, is to place a wire mesh, not too fine or too coarse on the under side of the felt beneath a layer of fiber. If this is done, a chain which should pass out at one corner of the cushion, must be well soldered to the metal condenser as if there is for any reason sparking, as there is certain to be if the connections are loose, it would ignite the cushion. The advantage of the wire mesh is that the cushion and condenser combination is flexible and fits the different styles of chairs with the backs in different positions. The advantage of having the condenser beneath the cushion extend nearly the full length of the cushion is apparent for purposes of current condensation the intent being to bring as much of the body of the patient as possible into the field of opposite electrical condensation.

*The electrodes* to be held in the hands of the patient may be either two electrodes attached to a bifurcated cord which is connected to one side of the d'Arsonval solenoid, or a single cord connecting a single electrode long enough to place the two hands upon it. Arrangements are also made by which the electrodes are fastened to the chair, the patient upon the couch placing the hands upon the electrodes. Any of these devices are practical. It is only to be borne in mind that the patient should hold both hands upon the electrode or electrodes so that the current will pass uniformly to the two sides of his body.

*A hot wire meter,* Fig. 40, is another indispensable factor to be used in connection with d'Arsonvalization. While these meters may not be entirely reliable and do not compare with a definite standard, if differences are not too great, they serve for general purposes as a practical means of measuring the relative heat production of the current

employed. An accurate standard should be adopted based upon a relative heat production by the constant current.

In these instruments the heating effect of the electric current in a wire of suitable resistance is by a special mechanism made to serve the purpose of indicating the current or potential in the measuring apparatus. The quantity of heat developed by the unit of current in the unit of time is the same for any kind of current, direct or

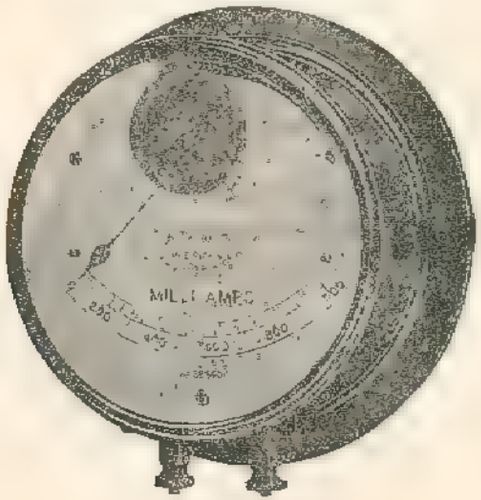

Fig. 41. Hot Wire Meter.

alternating (of any periodicity) and is quite independent of the phase or method of generation. The instruments should be made without magnetic fields or solenoids, in order that they will be entirely free from self-induction. The measuring or hot-wire is of platinum silver which is stretched between the two terminals; in the centre of this wire another wire of phosphor bronze is attached at right angles and held taut by a third terminal; near



the centre of the phosphor bronze wire, a cotton fibre is fixed on one end at right angles, at the other end passing round a special grooved metal a roller is fixed on a pivoted steel spindle, mounted in jewels and finally terminating in a small eyelet attachment to a flat steel spring. The whole arrangement of the fibre wire is thus subjected to tension and any slackening or "sag" of the measuring wire is immediately taken up by the steel spring and is transmitted by the phosphor bronze wire and fibre to the grooved roller which carries the pointer. By this method the smallest extension of the wire is greatly magnified and conveyed to the pointer, thus rendering the deflections easily perceptible. The means provided to reset the pointer to the zero position in case of need consist of a very fine pitched screw passing through one of the supports of the measuring wire. This screw which is adjustable from a hole in the case, moves very slightly an arm of the measuring block to which the wire is attached.

*Auto-conduction* possesses the same error as to significance of terminology as auto-condensation, the patient being the conductor of the current passively not actively, but acted upon by the current in its passage. *Body-conduction* and *body-condensation* would better convey the idea of these modalities, and cause less obscurity in the minds of students as they would convey correct impressions as to the method in which the physiological effects are produced.

*The method of body-condensation or auto-condensation* is applied by the arrangement shown in Fig. 17. The patient is seated upon the auto-condensation couch, insulated by the cushion from a metal sheet placed beneath,

which is connected to one side of the d'Arsonval circuit, the other side of which is connected to the patient usually by two electrodes to be held in the hands, which are connected by a bifurcated cord. When employed in this manner the patient's body is successively charged and discharged by the oscillatory or pulsatory discharges passing through the resonator. (See Frontispiece.)

The current in its passage under existing conditions has a tendency to accumulate with greater condensation to the surfaces or parts of the body nearest the condenser beneath the cushion. The d'Arsonval current however, is one of so low potential, that the charge in passing against the resistance of the body tissues seems to be largely diffused. Whether this warmth is due to an action upon the heat centers, or direct action of the current upon the tissues, or to the general diffusion of heat from the parts of the body which have become heated in the path of the current, during the administration, is a subject for consideration. If any part of the body is subjected to current condensation with the consequent heat production, the effort to maintain a body equilibrium of temperature quickens the general circulation, with the dissipation of the heated blood to all parts of the economy, as evidenced by a consequent glow of warmth at the surface. The tendency as indicated is greater under the relatively low potential of the d'Arsonval current for it to diffuse to considerable extent throughout the tissues and indicates that the effect may be largely due to the passage of the current through the tissues. The effects of the current upon general metabolism and blood pressure are very marked; and likewise indicate an effect which may be due to the general diffusion of the current.



*Auto-conduction* is administered with the patient lying or standing within a large solenoid. The passage of lines of electrical energy between the opposite sides of the solenoid, creates numerous currents in every direction throughout the body of the patient which becomes a conductor between the opposite sides of the solenoid. It is easily demonstrated physically, that a piece of metal placed within a small solenoid through which a current of

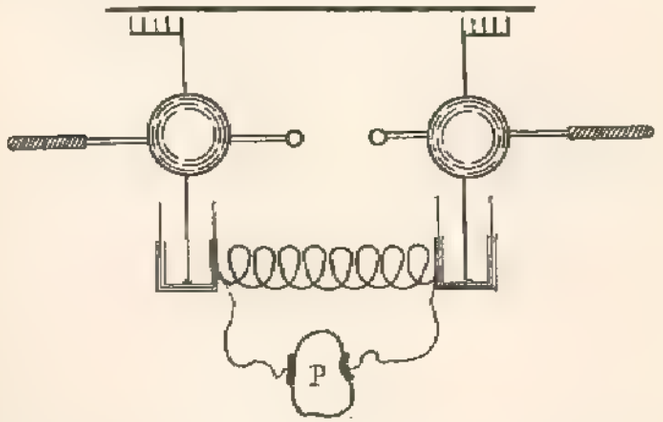


FIG. 42. Arrangement for Employing Direct d'Arsonvalization.

fairly large amperage and high frequency is passing, will be heated to a red or white heat. This is the principle of action, under regulation when a patient within a large solenoid experiences the thermic effect of the current generally throughout his person. While clinically demonstrated to be inferior to auto-condensation, it is evident that general effects must be produced throughout the economy by its uniform passage. The heat accumulated within the body under these conditions is quite uniform, but the effects upon blood pressure while

marked are not so reliable as auto-condensation. It is difficult however to determine as in auto-condensation just how this procedure affects blood pressure, for the *modus operandi* can not be readily demonstrated. With both methods the thermic effects are so manifest that there is strong evidence that it may be due to thermic action.

*Another method* of employing the d'Arsonval current may be designated the *direct method of d'Arsonvalization* The arrangement (Fig. 42) consists in placing two electrodes upon surfaces removed from each other; such electrodes being connected by rheophores to the two sides of the d'Arsonval circuit. This method may be employed either with two metal or two glass vacuum electrodes or one of each for the purpose of meeting various indications. The object of this method is chiefly for its thermic effects upon the tissues; induced for the purpose of producing hyperemia. It has been demonstrated that by this method a current of sufficient milliamperage, as measured by the hot wire meter, may be passed through a piece of liver or other meat, to actually cook it. Under these conditions, the greatest thermic effect is near the center between the opposite electrodes employed.

## CHAPTER IV

### THE TESLA AND OUDIN CURRENTS

THE *Tesla current* as produced by the originator, consisted of the arrangement of a primary coil the same as for the d'Arsonval current; and the secondary coil was placed around the primary and insulated from it within a vessel of oil. (See Fig. 16.) By this arrangement a step up current of high potential is produced, the tension of the current depending upon the amperage, length of wire, and number of windings in the primary, and the number of the same in the secondary. For therapeutic purposes, this current possesses very much the same qualities as the Oudin current, particularly so when the source is from a static machine, and one terminal of the Tesla is grounded. This current may be of very high potential and frequency. The potential in Tesla apparatus is of higher potential than the d'Arsonval current. The therapeutic effects are very much the same as of those of the Oudin and d'Arsonval currents for the induction of superficial hyperemia, and when administered from a static machine with large condensers, the discharges, synchronous with the spark discharge within the resonator are capable of producing considerable contraction in the tissues—effects very similar to those of the static brush discharge. The Tesla current is the least used of the high frequency discharges except as a step up between the d'Arsonval and the Oudin currents. When it is desired as in some types of resonators, particularly those employed with the static machine,

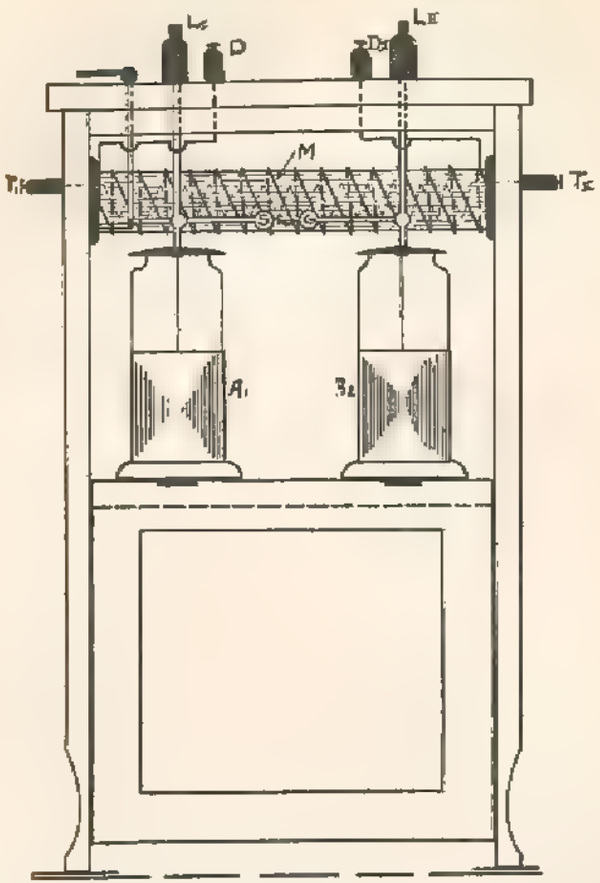


FIG. 43. DeKraft's High Frequency Resonator.
$A_1$, $A_2$, Large Leyden Jar Condensers; $T_I$, $T_{II}$, Tesla Terminals; $L_I$, $L_{II}$, Line Terminals to Source of Supply; $D_I$, $D_{II}$, d'Arsonval Terminals; S. G., Spark Gap; M, Mica Tube.

to produce a maximum potential, the Oudin solenoid is connected to one side of the Tesla instead of the d'Arsonval as shown in Fig. 43.

*The so styled Tesla current* produced with various styles of apparatus of the portable type, and so-called Tesla



coils, Fig. 26, have in many respects the characteristics of the true Tesla current. The discharges from these coils under regulation may be hot or mild with a regulated potential of delivery depending upon the length of the spark-gap permitted in the circuit. The field for this type of portable apparatus which are manufactured also for use with specially designed x-ray tubes for radiographic and therapeutic purposes, and in addition for the induction of local hyperemia, is the stimulation of local metabolism, and for the relief of mild types of congestion. They are also employed for the application of the effluvation method of destroying neoplasms for which purpose they are well adapted. It has also been stated that these apparatus are adapted for the auto-condensation method, which is an error, for the d'Arsonval current of lower potential and greater amperage cannot be duplicated by the portable type of apparatus. They may, however, to a degree lower high blood pressure, but do not produce the characteristic effects of the d'Arsonval current.

*The Oudin current.* The Oudin current, Fig. 19, designed by Professor Oudin, is a one pole modality; that is, the administrations are made from the extreme terminal of a solenoid the other end of which is connected either with a Tesla or d'Arsonval solenoid. The impedance and inductance of the numerous insulated windings of this solenoid, step up the current to a potential depending upon the source and number of windings which may be very great.

This current administered as stepped up from the Tesla of a static resonator, is very much accentuated or intensified if the other Tesla terminal is grounded. Under these conditions the current is to a very large degree pulsatory

or polar in effect. The method of Dr. Frederick deKraft of New York for administering this current is one of the important methods of employing this modality; applying it from a static resonator.

*The arrangement employed by Dr. deKraft* with the Oudin currents is valuable. When it is desired to produce the most profound effect constitutionally upon the patient, the application is made as connected in Fig. 43. An electrode, either a ring or a multiple point device, is placed in a tube holder or held in the hands of the operator, at a distance at which the pulsating effleuves will be perceptibly discharged against the patient. In order to intensify the effect a grounded metallic electrode may be placed upon the back or opposite side of the patient. By this arrangement it is possible to produce successive fibrillary and mass contractions of the muscular structures of the body, which remarkably stimulate metabolism and to a degree effect the resolution of local stasis. By varying the size of the electrodes and output of the machine, it is possible to localize this modality to any part of the body as, *for the treatment of ulcerated surfaces* with small ball or multiple point electrodes. The object of this form of treatment is two fold: (1) for the induction of local hyperemia in which it is peculiarly energetic; and (2) for the induction of active local or general metabolism. It is possible also by this method to lower high arterial tension.

*Fulguration is another method* which employs the Oudin current from various sources. The same method may also be employed with the Tesla or d'Arsonval current, the higher potential of the Oudin not being requisite for the application of fulguration.

# SECTION III.

## PHYSIOLOGICAL ACTIONS AND THERAPEUTICS OF HIGH POTENTIAL CURRENTS.

# SECTION III

## THERAPEUTICS OF HIGH POTENTIAL CURRENTS

### CHAPTER I

#### THE PHYSICAL EFFECTS OF THE HIGH-POTENTIAL CURRENTS

*The physical effects* of electrical discharges as applied in therapeutics depend largely upon their capacity to penetrate the body and the nature of their behavior when brought in relation to normal tissue under varying conditions; such effects depending upon the varying characteristics of both the currents and the tissues in accordance with physical laws. The study of these actions is fraught with less difficulty than the study of the actions of medicinal agents employed in therapeutics, because definite physical laws govern the activity, diffusion, and effects produced. The action of currents and other discharges upon animal tissue is generally demonstrable, certain, and reliable. Once proved that tissue contracts under an electrical stimulus, either by action upon the cell or the muscular mass, the same effect will, under normal conditions, be constant wherever muscular structures are found, deep-seated or superficial. We are thus enabled to determine with certainty the action of these currents upon the deeper-seated structures when we have learned by experience to employ the requisite potential, amperage, and frequency to affect them. So also is superficial cellular activity,—general or local metabolism,—is mechanically increased, the rule will be established that organs elsewhere, composed of the same tissue elements

under like conditions, will respond in the same manner when submitted to the same action. It is only necessary, then, to demonstrate definite effects when they become established laws, and we are enabled to anticipate and account for results with comparative accuracy. The application of electricity, when its laws of action and control are discovered, together with the relative effects of potential quantity and rate of discharge, becomes one of the most rational and reliable therapeutic procedures.

*The physical effects of electricity* upon animal tissue must depend relatively upon the characteristics of the modalities employed. The ratio of quantity (amperage) and potential (voltage) of the current determines, if high frequency does not render the action superficial, whether its action will be destructive (cauterant), electrolytic to a large extent, or act as a simple stimulant or *vis-a-tergo*, inducing increased functional activity.

*The nerves, either sympathetic or cerebro-spinal,* cannot be considered as electrical conductors conveying currents to their points of distribution. They are affected, on the other hand, as by a stimulant which excites the neuron and its axis cylinder to its characteristic action. There has been no demonstration, though often so inferred, which will justify the position that the nervous system acts in any way in conjunction with electricity as conductors *per se*. On the contrary, the arrangement of the nervous system is not such as will warrant such an hypothesis, ending as it does in terminal neurons without circuits. The centripetal and centrifugal impulses cannot by inference or demonstration be shown to bear any relation to electrical circuits; on the contrary, it has been demonstrated that nervous tissue is not the best conductor of electrical currents, but the tissues containing the largest vascular supply, as the blood vessels and muscles. Furthermore, nervous impulses are relatively very slow in passage as compared with the velocity of electric currents. It is of great importance in the consideration of the physical actions of electricity that we should recognize the behavior of the various electrical phenomena under different conditions, in order that we may accurately determine its destination, physical action, and physiological effects.



*Currents of different potentials* perform differently in their passage through the tissues. Static currents of *high potential* are *universally diffused* through the body when administered to a patient insulated and placed in direct connection from one side of the source of energy through an electrode or other connection coming in contact with an electrode placed somewhere upon the surface of the body, in accord with the law that such currents seek to immediately surround instead of occupy a conducting medium in a state of charge. They pass to the surface by the tracks of relatively least resistance and *in nearly straight lines* through substances having but slight variation in resistance, as do the relatively homogeneous tissues of the human body. Currents of *low potential*, on the other hand, *do not seem to enter the tissues at all* when connected with but one pole of a source of electrical energy. When such currents as those derived from the continuous-current battery pass between the two poles,

the current is *diffused into the tissues* laterally, as a sluggish stream coursing through a flat low land.

*Two essential properties* of all electrical currents affecting their action are the voltage (E. M. F.) or potential and amperage (quantity).

*Currents of great potential and large quantity* cauterize the tissues and destroy life by shock, overwhelming the cardiac or respiratory centers or by processes of dissociation of normal arrangements or conversion into other combinations.

*Currents of very large amperage* and relatively low potential are also capable of producing the same effects. These effects are also produced by currents of *relatively small* though not infinitesimal *amperage*, but having *extremely great voltage or potential.* When, however, the amperage of a current is so small as 1-5000 to 1-2000 of an ampere, the *voltage* or potential may be in *millions* and produce no dangerous effect. The latter are the currents of *high potential* without reference to frequency which are of great value therapeutically because they are capable of great diffusion mechanically, inducing activity of primitive cells and of the structures of which they form a part.

*Frequency of oscillation or alternation,* it has been shown by Tesla and others, renders currents of relatively large amperage and high potential not dangerous to life. This seems to be demonstrated to be due to the fact that these currents are, owing to great frequency, forced to pass over the surface of the body, or are widely dispersed without altering the superficial structures.



*Cauterant* effects of high-potential currents are produced by discharges derived from a source of relatively large amperage when brought near the surface, or by successive discharges of smaller amperage to the same area. This effect is produced by bringing the effleuve or brush-discharge from sources of high potential, in close proximity to the tissues—holding an electrode for a sufficient time in one position. The destructive actions and cauterant effects of these modalities are of relatively little therapeutic value, except possibly when it is sought to destroy local infection, a neoplasm, chondylomata, or other superficial abnormal process.

*Electrolytic action* is produced to varying extents by all electrical modalities, except possibly those in which the tissues are subjected to the action of currents of but one polarity, as the static wave-current and currents which do not pass into the body.

*With the currents of larger amperage,* however, electrolysis is most potent and of great value for producing the therapeutic results which are sought from such currents, but great caution against the reckless employment of currents of large quantity must be exercised. In the treatment of conditions in which it is sought to improve metabolism and increase the activity of organic functions, currents which produce ionic alteration without reference to consequence or selections, as do currents of larger amperage, must be employed with caution.

*Cataphoresis,* as produced by currents of high potential, is a subject upon which relatively little has been contributed. It has been demonstrated, however, by Bishop,

Burch, and others, that it is possible to introduce by such currents chemical agents such as iodine into the tissues.

*General diffusion of a current* requires that it be of fairly high potential and administered to a body or capacity insulated and connected to one side or pole of a source of electrical energy. Under these conditions the current should be of relatively small amperage, as are the static currents; or possessed of a high rate of oscillation or periodicity, when from a source of greater amperage. Two currents of otherwise distinctly different characteristics—the static wave current and the d'Arsonval current, as administered to the patient insulated upon the insulated platform or the cushion of the auto-condensation couch, from a directional source, are distinctly one pole pulsatory currents.

In the case of the former, the static wave current, the electrons are diffused. Attracted to escape to the opposite polarity in all directions, they pass under the pressure of high potential from the electrode in contact with the surface to immediately surround the body of the patient (see Fig. 44). The current takes this course in fulfillment of the natural law by which currents pass by the shortest route and best conductor. The human body is practically a normal salt solution; a good conductor; while the skin is a very poor conductor.

*When the d'Arsonval current* is administered by the method referred to, conditions are the same as with the wave current, in point of insulation and a unidirectional character when from a directional source; but the currents in other respects are different.

*The d'Arsonval current* is of much lower potential, and greater amperage than the static current, and though



derived from a high frequency apparatus is, under the conditions described, converted into a current of high periodicity. The current entering the body of the patient,

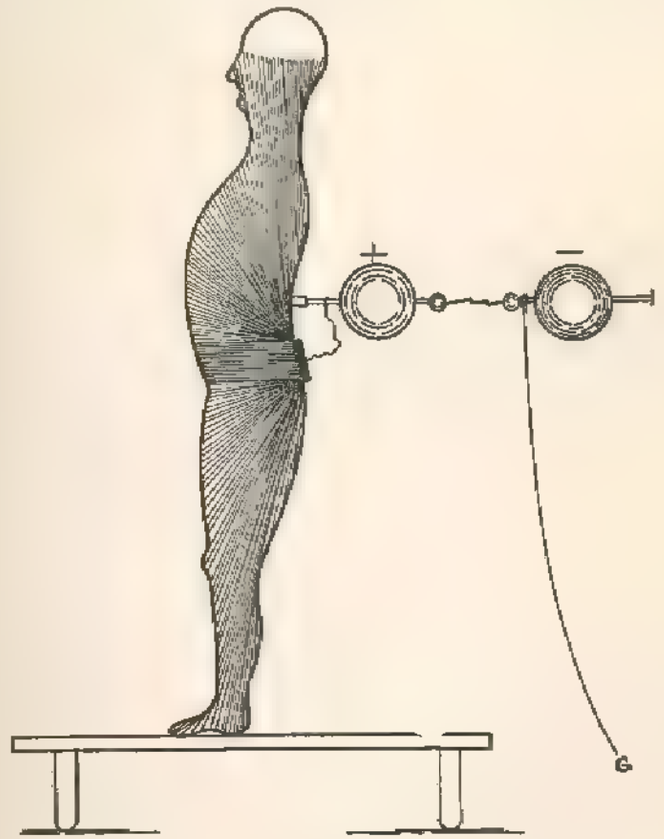


Fig. 44. Showing the Passage of the Static Wave Current Through the Tissues.

if of as high potential as the static current, would pass to and through the insulating cushion by the shortest route. Under the characteristic conditions, however, the current

passes through the body and is to a degree diffused. The greater condensation, however, must be present in the tissues nearest the condenser plate beneath the cushion, as indicated in Fig. 16. In both cases the current is practically unipolar, surging in and out of the patient.

*The static wave current*, owing to the small amperage with a slow rate of periodicity, produces deep mechanical effects upon the cells, with a small degree of heat production. With the d'Arsonval current on the other hand, the periodicity is so great, that the action is largely one of heat production, though the evidence of increased elimination of the products of poor metabolism are found here as with the wave current, by the increased elimination of solids with the urine and other evidences including improved nutrition and changes in the blood. In the case of the static wave current of low periodicity, the tissues beneath the electrode are thrown into active responsive contraction; whereas, with the d'Arsonval current administered as described, no evident tissue response is induced. These two currents, differing in quality and effect well illustrate and demonstrate the relative effects of varying amperage and the varying effects of high and low periodicity. The effects of both of these modalities as previously stated have a remarkable influence upon local and general metabolism.

A noted difference in effect is also observed with reference to their influence upon *blood pressure* or tension. The wave current is disposed to raise arterial tension, except in occasional instances, whereas the d'Arsonval current lowers blood pressure with but rare exceptions. How this action takes place is difficult to explain; probably, however, by heat production or some direct influence upon the vaso motor centers and the musculature of the arterioles.



*Muscular contraction* is induced by all electrical currents except those of high periodicity and high frequency when applied to the motor points or directly over the spinal centers, by direct or reflex stimulation of a nerve trunk, or the end neurons.

*Contraction of cell protoplasm* by electrical currents without reference to the nervous system has been unquestionably demonstrated, as all recent text books on physiology attest. All currents however, except the high potential currents, must be applied directly to the cell to produce responses except through the nervous mechanism. In other words, it is not possible by the Faradic or induced current to induce such contraction of the musculature through the skin. This however, is not the case with the static current which by a remarkable potential penetrates, overcomes the resistance of the skin, and acts upon the cells with great energy. The high potential static modalities induce diffuse contraction wherever applied, without reference to motor points. The contraction so induced is painless, except when the muscles are in a state of tension or when applied over an indurated tissue. Care must be exercised in the administration of the static wave current in carrying out this important principle of relieving or removing tissue infiltration or muscular spasm, not to overstimulate or fatigue the tissues. This is effected, and with best results, by regulating the length of the spark-gap that no muscular spasm will be produced and by not making the seance too long. A rate of spark discharge of 120 to 300 per minute for 20 minutes gives the best average of results.

On the other hand, the low potential currents when applied to the skin, produce a painful stinging sensation stimulating muscular contraction by end nerve irritation, and requiring, to produce a profound muscular contraction, that the current be applied directly to the motor points—places where the nerves come very near the surface of the body.

*The effleuve* as emitted from the brush-discharge, sprays, and vacuum electrodes are distinctly irritating to the surface and produce a rubefacient condition, and their consequent action upon deeper structures is at least in part due to reflex stimulation.

*Local oxidation and other germicidal action* due to the affinity of $O_3$ (ozone) for the organic tissues is another action which is exerted beneficially upon abnormal tissues and the germs present when exposed to the applications of the effleuve of the high-potential discharges due to the decomposition of the atmosphere and the products evolved from the mingling of the positive and negative electrons in proximity to the tissues with the production of ozone, nitrous acid ($NO_2$), water, and other combinations of less importance. The characteristic chemical effects are of a character which is but moderately irritating from the production of $H_2NO_4$ by the combination of $NO_2$ and water, which is produced in such small particles as not to seriously affect the tissues if the administrations are not too prolonged.

*The vibratory action* induced by the discharges of high potential arises from various causes. (1) Protoplasmic contraction is produced in the tissues by the current as it passes. (2) Superficial intense vibration is exerted by the action of the discharges upon the patient, insulated



but in the presence of oppositely charged capacities, and (3) the intervening skin, which is a relatively poor conductor, offers resistance, and the current passes beyond to a medium of good conduction. The effects are to set both the skin and underlying tissues into a state of vibration synchronous with the impulses of the interruption or oscillation at the spark-gap during the administration. The difference is marked between the skin and mucous membrane the resistance being much less with the latter.

*Intense local vibration* is most marked as produced by the conductive discharges at the place of contact with the metal electrode usually employed during the administrations of the static induced and static wave-currents, and also with the conductive feature of currents derived from the vacuum tubes connected directly with the static machine without the intervention of a step-up transformer or resonator. The effects of sensible pulsation are not so energetically produced by any other electrical apparatus as by the currents of the static machine.

*Polarization* is one of the most difficult of the physical properties to demonstrate. It has been shown, however, by physiologists that electrical currents in their passage through the tissues induce cell protoplasm to take spherical forms. All are familiar with the physical demonstration that magnetism and electrical discharges induce movable particles of matter to arrange themselves into various symmetrical forms. These actions signify an influence of electrical force by which mechanical effects are exerted.

*Ionization.* The demonstration by Thomson that the passage of an electrical current is the passage of sub-

stantial electrons is certain to place new constructions upon the probable actions of the currents upon the tissues.

*The physiological effects of the various high-potential modalities* derived from static machines and coils, either by direct connection or with intervening resonators or step-up transformers placed in the circuit, are practically based upon the same general principles, except those due to individual peculiarities, and have therefore been classified with reference to their characteristics as conductive, disruptive, and convective discharges, with added reference to the various sources and the varying conditions of the modalities. The effects produced by these electrical discharges are variable with the different modalities and have been given in detail in the preceding chapters.

# CHAPTER IX

## GENERAL PRINCIPLES GOVERNING THE THERAPEUTIC APPLICATION OF HIGH POTENTIAL CURRENTS

The consideration of the physiological actions as outlined in the foregoing chapters, suggests a very wide scope of clinical application for the high potential modalities. It has been observed that these currents possess three distinct characteristics of action, as follows: (1) the effects associated with *ionization, polarization*, and other characteristic actions of electricity; (2) other *mechanical effects* associated with muscular and cell contraction and vibration; (3) *chemical or antiseptic effects* characteristic of the convective and vacuum-tube discharges; and (4) *the thermic effects.*

If these currents are to affect the deeper tissues of the patient and produce a general effect, it is necessary either that the current administered be applied to the patient when insulated, and from one side of the source of electrical energy or by some other method by which it may be demonstrated to be diffused throughout the body.

*The wave-current,* administered as it is from one side of the machine with the patient insulated, induces discharges which diverge from the surface of contact to the whole surface of the patient, passing through the tissues of the body in every direction, thereby producing a general

electrification. It is in this manner that the influences of electricity *per se* are brought to bear upon the cell structures throughout the whole economy. While the action upon the cell is largely conjectured, it is clinically demonstrated from this method of administration that metabolism is increased and a general feeling of well-being induced. It is also clinically shown that patients not affected with organic lesions when receiving courses of treatment, have the normal functions of the system restored. This is evidenced by the markedly increased elimination and secretion, increased body weight, and a gradual restoration to normal proportions of the elements of the blood. These clinical observations indicate that a general increase of cell activity with restoration of their normal action is induced. When it is observed that this may take place regardless of a regulation of exercise and habit, it would seem that these administrations to patients whose habits and vocations are sedentary, take the place in a measure of physical exercise, probably due to the induced activity of the cell, which tends to preserve a balance in the economy furnishing a valuable means of eliminating effete end products and forcing tissue combustion. When employed, however, in conjunction with exercise, greater benefit may be derived. These observations therefore suggest that the person in a relative condition of health, but following a sedentary life, can be greatly benefited by the regular employment of such administrations. In the helpless invalid who is unable to take exercise, they are invaluable in that they induce nature to the active performances of her normal functions.



It is observed by those who are familiar the application of electricity by the *auto-condensation* method when employing the currents of high potential and high frequency or high periodicity, that there is also an increase of the products of the end-organs derived from its administration. These currents penetrate the body though not in the same manner as is fully considered in the previous chapter.

It seems to have been fully demonstrated that under both types of administration there is an increased elimination of solids in the urine and of $CO_2$ with respiration, which may arise from a large degree of heat production or superficial action, and these superficial currents may also reflexly affect the deeper structures of the body or induce other currents in the body. In the case, however, of a current administered as the wave-current is, from one side of the source of energy with the patient insulated, the current can be demonstrated to be actually driven through the tissues in all directions in the natural course to the surface, and the increased elimination so marked with this form of administration is undoubtedly due to the increased activity effecting an acceleration of general metabolism, both eliminative and secretive. These influences associated with the passage of any current through the tissues are productive more or less of electrolysis or ionization. The relative bearing of this action, however, upon the tissues is one concerning which no observations except the clinical results of their employment can be made. It is probable that the cells under the influences of the current, passing with interruptions, is one that induces a change of form incident to the contractions

and relaxations of the cell, and at the same time, with each recurrent oscillation, disposing the whole organism to a state of general tissue activity.

The administration of currents of high potential which flow between the terminals of the two opposite polarities certainly pass in narrow lines through the tissues to complete the circuit. The greater the potential or voltage of the current, the more direct will be these lines of passage between the two opposite polarities. The passage is comparable to a stream of water passing down a hillside or through a sandy plain. In one case, the channel will be very narrow and straight and only to a small degree saturate the banks, while the same stream, passing across a nearly level plain, will be tortuous and largely absorbed during its passage. This comparison would serve to indicate the different methods of passage of currents of high potential in comparison with the continuous current of low potential which is known to spread out through the tissues during its passage. One other observation in relation to these two types of current should be made, and that is that the current of low potential is disposed always to follow the tracks of best conduction, as the muscles or blood vessels of the body, while the currents of high-potential, displacement-currents, pass across and through tissues of slightly varying resistance in comparatively straight lines. The greater the quantity of the current passing, the greater will be the ionization or electrolytic action upon the tissues, except of high potential currents of high frequency, which have been demonstrated to produce no electrolysis, but *thermic* effects.



*The mechanical effects* of high-potential currents must be deemed of great importance from the therapeutic point of view, and may be exerted either directly or reflexly, according to the modality employed. The direct effects of these currents are derived from the conductive discharges, producing distinct muscular contraction and vibration, and undoubted contraction of cell protoplasm from their application. These effects from the conductive discharges are very largely local, being transmitted from the surface to a depth relative to the amplitude or *potential of delivery* of the current, which is varied by changing the length of the spark-gap.

*The term potential of delivery* is one which the author has adopted to express a condition of electrical discharges which should be defined, and for which there is no term in common use to designate. By it is meant the amplitude or spark length possible to deliver under the conditions of a circuit from a discharging electrode to the site of application. *The potential of delivery* will depend upon the length of the spark between the rods of the condensers, plus the potential added by a step-up transformer; the length of an effleuve of a convective character; or the length of spark-gap or the amplitude of the conductive discharges which are measured by the spark gap. The size of the Leyden jars in the circuit of the current also varies the possibilities of the amplitude. The necessity for the employment of the term *potential of delivery* arises from the confusion that exists at this time with reference to the action of high-frequency and pulsatory currents. Too little attention has been paid to

the fact that when rapid interruptions are made in the circuit of a current pulsatory or oscillatory, that the periodicity is at the expense of the spark length possible if a brake is made in the circuit. Potential of discharge is shortened to produce a high rate. The spark discharging between the jars of the resonator of a high-frequency apparatus will be relative in rate to the length of the spark discharging, other things being equal. The length of a spark discharged from an electrode connected with the circuit will represent the *potential of delivery.* In other words, when administering a spark from a solenoid or Telsa coil or a combination of the two in connection with the outer coating of the two condensers of a static machine, a spark will be delivered relative to the length of the spark-gap, and of a rate of discharge increasing as the spark length is diminished or the rate of revolution of the plates of the machine is increased, plus an increase of potential developed in the solenoid. It will be seen, then, that the rate of interruption is increased at the expense of the *potential of delivery.* When, therefore, the fact is recognized that the intensity and the depth of perturbatory effect of a discharge depend upon its *potential of delivery,* and not upon the frequency of interruption, other things being equal, the importance of the designation and differential relations of potential and the rate of interruption can but be appreciated. The rate of interruption bears the same relation of inverse ratio to the potential of delivery in electrotherapeutics as speed does to power in mechanics. In the consideration of the mechanical effects of the electrical discharges conductive, disruptive, or convective, the importance of the bearing of these considerations can be easily appreciated. *The mechanical effects of the currents of high frequency* except when painful in character, as are the sparks, or effleuve, and the possible action upon the cell due to the influence of the passage of an electrical current as considered, are otherwise practically nil. In other words, the currents of very high rates of interruption—pulsatory or oscillatory—are deficient in amplitude, do not produce muscular contraction, and are absolutely painless during administration. With them the potential of delivery is very small. The mechanical effects of such currents are therefore insignificant or of no value. The following conclusions as to the actions of high-potential discharges constitute a basis for their *mechanical* employment in therapeutics.



(1) *Currents derived from the static machine* have striking characteristics producing mechanical effects upon the tissues diffused, penetrating and painless, peculiar to these currents. When carried to the point of inducing tetanus, or when administered over inflammatory areas, their action may also become painful.

(2) *Secondary mechanical effects* are undoubtedly produced upon the tissues, which give tone to the muscular structures, and others probably of polarization.

(3) *Muscle and tissue contractions* are produced by all disruptive and convective discharges relative to their intensity or irritating characteristics, and varying in penetration with the potential of delivery of the discharges, other things being equal.

*Polarity.* In the administration of the high-frequency currents—alternating in character—consideration of polarity does not enter. Such currents, as the designation implies, are alternately positive and negative at the two terminals of the circuit. This is objectionable, when it is a well-recognized fact that with unidirectional currents the local actions of the opposite polarities produce positively different effects.

*In the local administrations of the wave-current* in the treatment of acute inflammatory conditions, the writer has demonstrated repeatedly—often enough to establish the fact—that the wave-current derived from the negative side of the static machine when applied over such regions, while producing a *temporary* sedative effect, is followed after a short time by marked aggravation of a condition which had been improving. It has occurred in a sufficient number of instances during previous years when the polarity was looked upon as an indifferent factor to finally demonstrate the fact.

One well-marked instance will serve to illustrate the aggravating effect of the use of the wave-current connected directly to the negative side of the machine. A patient who had been treated for three days for an acute sciatica of a very severe type, in which the condition had been so greatly improved that he had slept the night previous to the fourth administration, was treated by an assistant. He connected the patient with the negative side of the machine, the positive being grounded, and administered the wave-current for the usual period of fifteen or twenty minutes. The patient left the office in a seemingly comfortable condition, without pain. On the following morning it was with difficulty that he could return to the office, requiring assistance to get on and off the cars and into the house for treatment. The wave-current was then applied in the usual manner connected with the positive side of the machine, after which the patient left the house with no vestige of pain or suffering and continued the course of his treatments for three days, when the recovery was complete. Similar results have occurred in other cases in which, with the use of the positive current, uniformly sedative results are obtained. It is the local action, especially in the treatment of inflammatory processes, where the polarity plays such an important part. It would also seem, and, so long experience has taught the writer, that the positive electrons exert a more favorable influence upon the general metabolism. Comparisons, however, of the two polarities have not been made as to the constitutional effects of the current, as the negative has been but little used in these conditions. From the positive, however, are always obtained desirable, sedative, and quieting effects which seem to indicate its employment, if not its choice, to the exclusion of the negative, for favorably affecting the nutritive processes of metabolism.



*The application of the brush-discharge,* with the patient connected to the negative side of the Holtz machine, is distinctly soothing to a painful and inflamed condition, as may be easily demonstrated. When a connection is made directly to the positive side, however, the effect is distinctly irritating. This is not only the effect at the time of an administration, but the writer has been con-

vinced after a series of experiments that an application with the patient attached to the positive side, will be followed by a recurrence of the symptoms a short time after the close of the administration, whereas, when the application is made with the patient connected to the negative side of the machine, the effects are soothing and sedative and the relief of the inflammatory process from a proper administration is prolonged, tending to the recovery of the condition. This unquestioned local action in connection with the administration of the brush-discharge proves clinically the certain indication for the choice for the connection of the patient with the *negative* pole during this form of administration.

*With the vacuum tubes* applied directly to the surface of the patient, the choice of polarity is to some extent an open question, but from recent results it seems to have been demonstrated that the connection made to the positive side of the Holtz machine is the choice for the treatment of local inflammatory conditions, where it is sought to allay the induration and restore an active metabolism. When the indications are for the treatment of local septic conditions, however, or where germs are present in the superficial tissues, the greater chemical action at the surface of the glass when connected with the negative side would indicate the connection with that side for the treatment of such conditions. In this connection it is well to state that the effects of muscular contractions are induced with a great deal more energy with the same length of spark-gap when the vacuum tube is connected with the positive side of the Holtz machine, than with the negative,



and also that greater energy is exerted when there is a leading-in wire in the electrode.

These effects suggest an important consideration of the actions of the electrons in their passage, but leave an element of doubt from the fact that when the brush-discharge is employed there is a passage by induction through and to the place of discharge of negative electrons, while with the wave-current the passage of the current surging to and fro is of positive electrons. In one instance the consideration is given entirely to the one polarity as it affects the surface during its escape, whereas, in the other instance, the opposite polarity produces the greater degree of sedative effect.

The explanation of these two opposite effects from different polarities is difficult to reconcile, and yet from clinical experience, which is the best proof, the truth is demonstrated in every instance where a careful study of the relative effects is made. So much of the action of these electrons upon the tissues is still unexplained, that the clinical results obtained may lead to final conclusions which may clear up or explain many of these actions.

The explanation of the differences of these effects must be made, not from effects of the passage of the current, but probably from the irritating action of the positive discharges of the brush-discharge upon the end-organs, which is easily demonstrated by any observer.

The polar effects of the d'Arsonval current as administered with auto condensation have not been generally appreciated. This current when administered from a unipolar source, i. e., with an arrangement which will vary with the length of the spark-gap, and other adjustment of the source of the current charging the reson-

ator is rendered a unidirectional or pulsatory current. When derived from a static machine or Ruhmkorff coil, or other apparatus which gives a relatively unipolar current, the resistance of the spark-gap, and of the cushion on the couch, and the capacity of the patient, the current is converted into a pulsatory current of high periodicity. Such a current is practically unipolar in character, with the polarity regulated by changing sides with the d'Arsonval. In the writer's experience, the d'Arsonval current administered by auto-condensation produces its best effects upon metabolism and in arterial hypertension when administered with the positive to the patient. In this effect it naturally corresponds in its action with the effects of the positive pole of the static wave current.

*The thermic effect of the high frequency currents* when administered by the direct d'Arsonval method, that is by the passage of the current through the patient directly between two electrodes placed upon the surface, produces a remarkable action upon the intervening tissues, by the induction of hyperemia. By this means it is possible to derive remarkable effects in the treatment of infection and conditions associated with impaired metabolism. Probably no therapeutic measure offers greater possibilities than this method of local treatment by hyperemia. The current in this event is largely oscillatory as is characteristic of the d'Arsonval current when administered with electrodes from the two poles in contact at two places upon a conducting body.

*From the therapeutic point of view*, the importance of *muscular and cell contraction* and of vibration is of the greatest importance. The latter is so closely allied to muscular contraction as an effect that it is difficult to dis-



cover a distinct differentiation. It will be generally appreciated that most diseases arise from functional inactivities associated with *hyperæmia*, passive or active, and *congestive processes* induced by irritants which appear in the form of germs, the products of auto-infection, results of poor metabolism, or as the effects of traumatism. These conditions as stated are associated either with a degree of sluggish activity or with a condition of induration associated with local stasis.

In nature's method of walling off processes of infection, stasis is established and serves a valuable purpose, when infection is present. The same induration which is nature's *wall of safety* against the spread of infection is the greatest obstacle to recovery in other inflammatory affections. To relieve these conditions of local stasis or induration, which interfere with the restoration of normal circulation and ultimate absolute restitution, some energetic means is required. If the affected area is superficial, the application of a mechanical means will act as a *vis-a-tergo*, overcoming the induration, softening the tissues, and thereby restoring circulation and permitting the elimination of accumulated infiltration, and other products of an inflammation. It can but appeal to the mind of the intelligent reader that such a procedure is indicated before a normal restoration can follow.

*Induration* promptly follows trauma, as a sprain. The blood rapidly accumulates, and the tissues become hard, swollen, and indurated, with the ultimate establishment of what will become a chronic stiffening and impairment of the functions of the part. Thus, in consequence

of a shock sustained by the exposed tissues, dilatation of the capillaries and blood vessels, with the determination of an excessive quantity of blood to the part, becomes the first step towards the establishment of a chronic process. Nature has provided an increased blood-supply whenever an accident occurs in the tissues and repair is necessary. Under physiological conditions without the production of shock or severe injury, a compensatory supply of blood enlarges and develops the part, which is called into most energetic action; but if an accident occurs which results in an excessive supply for which there is not a corresponding demand, as above stated, swelling and induration result. For the removal of such a condition no compensatory action is provided, and local stasis, which will become a chronic inflammatory process, is established. The application of mechanical measures for the relief of local stasis, as it occurs either in association with trauma or infective processes, may be followed by prompt restoration. When, however, induration walls off cavities of infection where considerable pus is already present, to remove the induration would be to extend the infection.

While the application of other mechanical measures to conditions of stasis will induce circulatory drainage to a certain degree and re-establish to some extent the normal processes, their action is far less satisfactory than the application of the high-potential electrical currents; (1) because they do not produce contraction of the tissues to the extent that it is produced by an electrical current; (2) because the contraction induced by an external mechanical stimulus, not electrical, has not the same tendency to preserve a prolonged state of contraction; (3) because the penetrating effect and diffuse action of the mechanical applications referred to are not such as to envelop and include all of the structures involved, and (4) their application is generally too painful in acute conditions to permit the production of complete relief of the local condition.



The *modus operandi* of the high potential electrical applications of moderate rates of interruption, as applied to the treatment of acute congestion, is to stimulate the tissues to contraction, alternating with periods of relaxation. The induction of contraction, interrupted at intervals not too frequent, reduces a process of inflammation to normal. The flow of blood in the parts is thus restored and the activities of the lymphatics and end-organs which under pressure were in condition of stasis are restored.

It will be readily appreciated when an electrical stimulus is administered in the manner described, before much pus has formed in a commencing abscess, as of tonsilitis, felon, or carbuncle, it will overcome the local stasis, and at the same time increase the local leucocytosis and, causing more activity locally of the phagocytes, will carry away the foci of infection and relieve a condition which would otherwise be followed by a painful process. This is undoubtedly the method of action, under a systematic application of the proper high-potential modalities to acute inflammatory processes.

*In cases of mechanical injury,* in which no foci of infection are present, but a condition of injury to the soft parts, the effect of relieving the local congestion is all

that is required to relieve a process, which, if treated by other methods, will generally become chronic and be followed by months or years of suffering and inconvenience. When it is generally recognized that mechanical action is necessary to restore the normal circulation to an inflamed tissue; that its employment is the step of first importance for the relief of a non-infective or the early stage of an infected process; and that the action of high-potential discharges of low rates of interruption, which produce the effects of muscular and tissue contraction, are indicated, uncured non-infective, chronic inflammatory conditions will be rarely encountered.

*In chronic conditions* in which the early application of proper treatment has been delayed, the relief, while generally certain if persevered in, is not prompt because the products of inflammation have become more or less organized, and deposits of fibrin, and round-cell infiltration, and other products of inflammation, have become so extensive in the area that for their elimination a longer time will be required. Furthermore, when anchylosis is present, except in the superficial regions, little can be expected from the high-potential treatment unless the adhesions are first broken up, after which no means offer greater promise for subsequent relief and cure of chronic joint affections than the various applications of the high-potential currents and other modalities. In these cases, however, the long static sparks and wave-current administered with a very long spark-gap are requisite, because, in order to overcome the chronic induration, very penetrating effects are required. In the author's experience,



few joint affections where anchylosis or erosion has not occurred and no active germ process is present, will fail to respond to the systematic administration of high-potential electricity. In enlarged or congested glandular conditions resulting from poor metabolism, or the presence in the tissues of effete materials, substances that have not been eliminated, these high-potential currents are as a rule effective.

It is a recognized fact with those who are familiar with the uses of these modalities, that in glandular conditions, where hyperplasia or some organic destruction has not already taken place, it is possible by the mechanical action of these currents to restore in whole, or part, normal conditions, and that in cases in which an organic process of a slow inflammatory character is in progress, it is often possible to abate it, allay its progress, and remove the inflammatory exudates that are present, thereby largely improving the local conditions. This is notably true in prostatitis. In hypertrophic cirrhosis of the liver, chronic diffuse nephritis, chronic parenchymatous nephritis, in the early stages, and also in affections of the spleen, pancreas, and other glands of the body, the principles enunciated indicate their employment, and results obtained have demonstrated their utility.

*The potential of delivery,* in all cases, must be relative to the depth at which the lesion is seated, or the volume of the structure affected, and the results of their administration will depend upon the possibility of transmitting the electrical vibration and tissue contraction to the remotest part of the affected organ or region. This will de-

mand in many cases the administration of very long sparks, or the use of a very long spark-gap in connection with the conductive discharges. The modalities which partake of these qualities, producing muscular and tissue contraction, are the currents controlled to low rates of interruption, as the static wave-current and the static induced current, and the stimulating reflex effects of the direct sparks from the static machine and to a lesser degree the high-potential sparks from the resonator, or solenoid in connection with coil or static machine. The vacuum tubes, when employed in connection with the static machine, also produce distinct vibratory action and contraction, whereas, from coil sources the only effects of tissue contraction produced are those which are induced by the irritating effects of the discharges with the production of reflex contraction, without the distinct vibratory influence. It will be seen, therefore, that for the treatment of inflammatory conditions in which the intent of the administration is to produce circulatory drainage and local elimination, it is best stimulated by the induction of tissue contraction and local vibration, which are effected most energetically with the currents of lower rates of interruption and high potential.

Too much emphasis cannot be put upon the value of these mechanical effects of high-potential electricity, which have been generally ignored by writers in the past.

*By the rational employment* of these modalities it has been already demonstrated that numerous chronic conditions can be alleviated and the normal local circulation



and nutrition restored to the parts when other means have failed.

*The treatment of infectious diseases* by high potential currents must be managed from an entirely different point of view than the treatment of other inflammatory conditions. The abscess has been opened when fluctuation was present and treatment confined to the use of means that favored the development of the pus process, "bringing it to a head" as was the common expression. More recently a crucial incision and the injection of carbolic acid has been employed to abort a boil or carbuncle—a painful process and not always successful. Since the demonstrations of Metchnikoff, Wright, and others of the certain functions of the microphages and the macrophages—the leucocytes and the tissue cells, the management of infectious conditions has become constantly more rational. It will be recalled by every physician who has employed agents which produce a diffuse hyperemia in an infected tissue, that it has been possible in some instances to abort abscess processes. The prolonged application of heat at high temperatures in connection with other counter irritants which produce locally an intense hyperemia, increases in the tissues involved, by increasing the blood supply, a relatively larger number of phagocytes. It is this principle which is taken advantage of in the treatment of infection with the high potential currents.

*Methods inducing hyperemia* with the high potential currents are (1) those which act superficially, as the vacuum tubes or effleuves—discharges which on account of their irritating or stinging character induce a liberal influx of blood into the tissues; and (2) the high potential current of high frequency or high periodicity and fairly

large amperage, which, when passed directly through an infected tissue, induces a degree of heat in the interpolar tissues. Naturally when a tissue is heated blood flows in through the dilated capillaries to maintain a uniformly normal temperature. By this means a continued passage for from ten to twenty minutes of a direct d'Arsonval current through the infected tissues is capable of inducing a marked hyperemia in the parts intervening between the surfaces to which the two electrodes are applied, thereby effecting even in the deeper structures a heating of the tissues which will persist for some time after discontinuance of the administration. These and the application of radiant light and heat which penetrates deeply into the tissues with a conversion of the radiant energy into heat units, are the two most important means of inducing deep hyperemia.

*The Roentgen ray must be considered* here in connection with the treatment of infection, though but a product of the high potential currents. Its characteristics are such that its influence upon germ life is most remarkable, seemingly sterilizing, not destroying the germs in the field of infection, when the dose is large enough or when, administered intermittently for a long enough period of time. In the active processes, as those of streptococcic or staphylococcic infection, the dose should always be a massive one; i. e., it should be applied for a longer time if a moderate radiation is employed, or otherwise for a relatively shorter time. In the terms of Saboraud, a full Saboraud dose should be applied directly to a carbuncle or abscess, or a twenty to forty minute application of the usual x-ray dose, that is used for the treatment of epithelioma, on alternate days of ten minutes each. The inhibitory effect of such a dose of x-rays is remarkable in its action upon germ life. It should be followed in twelve to twenty-four hours by an energetic use of radiant light and heat and high frequency currents—sufficient to maintain a profound hyperemia in the infected tissue. Such procedure is usually effective in aborting a local pus process when the opsonic index is normal. In the treatment or tubercular adenitis, a similar routine may be followed with the persistent use of the high frequency current and radiant light and heat, following a prolonged dose of the x-ray, until the process is entirely arrested. It should always be borne in mind that radiant light and heat and the high frequency currents likewise have an inhibitory effect upon germ life, and coincidently increase the percentage of hemoglobin in the blood, and often with it the establishment of a higher opsonic index.



*The local antiseptic or germicidal action* of the high potential discharges, either from effleuves or vacuum tubes, is limited to the action locally when kept up for considerable time. It is questionable whether the effects penetrate deeply into the tissue. Added to these are the effects of the higher frequencies of light, particularly the violet and ultra-violet associated with the emanations from these discharges. It has also been demonstrated that certain chemical substances as iodine and the essential oils are to an extent taken up by the tissues through the medium of the vacuum tube discharges.

The production of an oxidizing agent so rich in ozone, in proximity with the germs, insures a certain amount of destructive action from that source. So also, the nitrous oxides which are derived from these discharges are antiseptic in action. It must be recognized, however, that the

action of these discharges is very superficial; for the discharges from the tissues take place from the most superficial points and are also produced in the intervals between the vacuum tubes and the tissues or in the spaces between the surface and the electrodes employed in the administration of the convective discharges.

It cannot be presumed that any spark discharge takes place within the tissues of the patient, nor in any case has it been demonstrated, that the chemical effects of the discharges are to a considerable extent conveyed beneath the surface except by the immediate effect of the action of these agents upon the blood in the most superficial capillaries. The extent of their actions show that so far as the effect upon the germs is concerned, the action is local and very limited. To effect anything like a therapeutic result upon the integument or a mucous surface the electrode, if a vacuum tube is employed, must be in close contact with the tissues.

*The radiant energy induced* by the electrical discharges has an undoubted though mild effect upon some forms of germ life, probably equally as much as the ultra-violet rays of the solar or arc light spectrum. It is therefore possible in the treatment of superficial conditions and in processes in the cavities of the body, where the vacuum tubes can be placed in close relation to congested or infected tissues, that a materially beneficial effect will be derived from their action upon germ life.

From the above observation it will be appreciated that a large range of indications exists for the employment of high potential modalities in the treatment of all types of inflammation. In subsequent chapters details will be given of the various applications to special conditions.

## CHAPTER IV

### THE HIGH POTENTIAL CURRENTS IN DISEASES OF THE CIRCULATORY SYSTEM

THERE has probably been no advance made in therapeutics which will contribute more to life and longevity than the introduction of the high potential currents in the treatment of arterial sclerosis and its causes. That such statements are not recognized by the rank and file of our profession is due to the fact that the use of electricity is looked upon as so technical that the average man is unwilling to investigate the methods of employing it, and for this reason is apt to be doubtful of its efficiency. The value of these currents, however, has been well established and the eagerness with which those interested are investigating this branch of medicine is encouraging.

Hypertension is now generally acknowledged as the common cause of sclerosis of the middle or muscular coats of the arteries resulting undoubtedly from the fact that a muscle maintained in a state of tension is certain to undergo degeneration owing to the consequent interference with the circulation and metabolism under these conditions. This is demonstrated in the degeneration that takes place in long muscles which are for a long time in a state of muscular tension. The degeneration is first of the fatty and then of the calcareous transition, in which the middle coats of the arteries are found in advanced arterio-sclerosis. Other factors, undoubtedly, as conditions

of malnutrition favor the degenerative process in the arteries. Syphilis has also been shown to be a cause of arterio-sclerosis. The important study therefore, looking to the prevention and relief of arterio-sclerosis, is the management or prevention of hypertension.

There are various influences which under normal conditions affect arterial tension. The athlete, as the young man on the college rowing or football teams, or the professional who trains to perform feats of strength and agility, maintains his muscular condition under such a degree of exercise, that the heart's force must be increased to perform the extra work put upon it when the tension is relatively increased. Then, as in all cases of hypertension there is a coincident hypertrophy of the ventricles of the heart. Under extreme exercise the tension will increase from the normal 110 or 120 mm. to 130 or 140, or even 150 at which after hypertrophy is developed, it will remain constant unless for some reason the abandonment of active pursuits permits a gradual lapse in the force and tone of the heart muscles, due to a gradual atrophy with the dilatation persistent, which brings the heart into a state of incapacity or failing compensation, when the blood pressure gradually falls far below the normal. During the past year the writer has noted the tension of young athletes under exercise ranging from 10 to 30 mm. above normal; and one young man, a young college student who had for three years worked upon the rowing team of his college, after three weeks of rest exhibited a blood pressure of 150 mm. In another instance, that of a young physician who had previously been an athlete on a college team, the blood pressure was found to be at 70 mm. indicating the ultimate sequelae



of the injudicious extremes of exercise in those, who may later lead sedentary lives. The causes which induce hypertension are: (1) *the resistance in the circulatory channels,* due either to the contraction or stenosis of the arterioles or congestion of the liver and kidneys through which most of the blood must flow; or (2) *increase in the volume or quantity of circulating fluid;* or (3) the *increased heart force induced by the demands* made on the system during exercise, as previously shown; or from emotional causes; or (4) *the ingestion of alcoholics or other drugs* which produce a contraction of the arterioles or exert an increased force of heart action; or (5) altered viscosity of the blood.

*The associated pathological arterial conditions,* found present with hypertension, are probably in most cases the consequence and not the cause of hypertension. This view is now generally accepted, and though, for a long time, it had been the opinion of the profession that Bright's disease was the cause of arterio-sclerosis, at present it is recognized to be the consequence. *In parenchymatous nephritis and cirrhosis of the liver* however, the circulation is obstructed by the engorgement or subsequent atrophy, producing a hypertension.

*In parenchymatous nephritis,* the hypertension is compensatory and does not lead to arterio-sclerosis, and must under no circumstances be disturbed by lowering of blood pressure.

*The study of hypertension* has in recent years been greatly facilitated by the invention and introduction of practical instruments for measurement, the most accurate of which are based upon the principle of restraining the circulation of the forearm by a band or girdle, made to

constrict the soft structures of the arm; the pressure exerted upon the blood vessels causing the pulse to disappear at the wrist. The pressure required to overcome the resistance against the propelling force of the heart, when constriction is made by an inflated rubber sack beneath the constricting band, is measured by the height of a column of mercury having a graduated scale and which is subjected under the arrangement to the same pressure that is exerted to restrain the circulation. When pressure is released from the circuit, the mercury column falls gradually, when at a certain reading the pulse returns. The reading at the instant of return of a full normal pulse will indicate the force being exerted by the heart; or the relative arterial tension.

Several types of sphygmomanometer have been manufactured to meet these requirements for the purpose of measuring arterial tension, most of which are constructed upon the principle of the Riva-Rocci as described. The measurement is based upon a relative pressure exerted upon the column of mercury in circuit with the same pressure exerted upon the arteries of the patient and read in millimeters of mercury. There can be no question as to the accuracy of those of the type described which are constructed to operate with a mercury column. Another apparatus which is calibrated to read the same as a mercury column, is constructed on the principle of the aneroid barometer and is very sensitive to variations in pressure. Those constructed with coiled steel springs are not apt to remain accurate as under various climatic changes with humidity the iron is apt to become rusted, and the springs relaxed.

The introduction of these instruments of precision for



measuring arterial tension has placed the profession in a position to judge accurately of the relative conditions as to the presence of hypertension or a resulting arterial sclerosis, it having made it possible to make practical studies which could not be made by reliance upon the sense of touch. As the thermometer is definite in the measurement of temperatures, so is the sphygmomanometer in the measurement of arterial pressure.

*The normal blood pressure,* as shown experimentally in observations upon a large number of patients of all ages and conditions, seems to be for males between the range of 105 and 120 mm. and for females from 90 to 110 mm., subject to relative conditions as between the sexes—physically strong and athletic women often showing a normal reading as high as 120 mm. while in men of effeminate structural type the pressure may fall as low as 100 mm. These standards are based upon the study of hundreds of cases under treatment and otherwise, and the findings have shown that in a very large number of adults in good health, at fifty and even sixty or sixty-five years of age, the blood pressure does not exceed 120 mm. This occurs in individuals usually of a careful habit of life who have eaten moderate quantities of food, and avoided consumption of alcohol and stimulating foods to excess. On the other hand, it is often found that in young adults particularly those who are inclined to consume food without regard to exercise, that the blood pressure may be even as high as 150 to 170 mm. The average adult at forty-five to fifty years of age, will show an arterial pressure ranging from 140 to 160 mm., but for no reason should such tension be called normal at any age. In most cases when the blood pressure exceeds normal, it may be accounted

for in the habits of the life of the individual, when his health is otherwise objectively unimpaired, but conditions have arisen which induce hypertension without the presence of other symptoms.

*The causes of hypertension* are of natural interest in connection with the investigation of methods of treatment.

It seems now to have been demonstrated beyond any question that conditions within the alimentary canal have more to do with the establishment of hypertension than other affections. The common habit in a country and with a people, who have an abundance of good food and drink provided several times daily, is to overeat. Over indulgence and excessive eating, particularly of foods rich in proteids, as meat, are most objectionable. It cannot be stated however that carbohydrates in connection with excessive feeding do not also play a role in auto-intoxication processes.

*An excessive quantity of food*, improperly masticated or otherwise, constitutes the chief source of intestinal fermentation, affording as it does from all foods that are undigested and unassimilated culture media for the growth of bacteria in the intestinal canal particularly in the colon. That bacteria and their toxine products under such conditions are a prolific source of irritation, in the blood, acting either as direct irritants to the muscular coats of the arteries, or affecting the tension through some action directly upon the vaso-motor centers, possibly by affecting the adrenal system, seems to be established.

*Regulation of exercise to the food consumed* is another factor upon which depends to a large degree the regulation of metabolism, leading to conditions which induce hypertension. For in individuals who live sedentary lives,



and eat immoderately, the disposition to hypertension is marked, whereas, in those who lead laborious pursuits, the consumption of large quantities of food may not induce hypertension. The demands of the system and activity of the absorbents under such conditions seeming to rob the intestinal germs of the nutrition necessary to their growth.

It is, therefore, of the utmost importance in cases in which hypertension is diagnosed, to give attention to all important features of habit, in order that the causes may be eliminated. A diminished quantity of food is indicated in most cases. The correction of diet by the limitation of proteid, particularly animal proteid, in cases of marked hypertension, and the institution of regulated exercise in those whose habits are sedentary, is indicated. Walking, golf, tennis, hand ball, or other active gymnastic exercise should be instituted as a routine regime with all patients in whom the blood pressure is rapidly lowered below 140 mm. even though the initial reading had been above 200 mm. It is possible in many of these cases after a short time to altogether control the conditions by the regulation of exercise and diet; but not at the outset.

*The electrical treatment of hypertension* is one of the most important discoveries in the management of these cases. It far surpasses the employment of any drug medication or the Nauheim baths, and when employed in connection with regulation of the habits of diet and exercise, as previously suggested, it is possible to lower arterial tension very materially, and to maintain it at an entirely safe range, even in advanced cases of arterio-sclerosis. In considering the management of these cases, the writer has adopted a classification based upon the patient's response

to treatment, finding no other in the literature. It is a well established fact in the experience of all who have made considerable use of the auto-condensation and auto-conduction methods, that with twelve to fifteen minute seances, employing approximately 500 milliamperes as measured by a hot wire meter, it is possible to lower the blood pressure from ten to thirty millimeters of mercury, except the advanced cases of arterio-sclerosis. The author has had under observation eight cases in which there would be a fall of from three to five mm. but under daily treatment no progress was made, the tension not falling as it does in other cases.

*These resisting cases,* occurring as they do in old people, demonstrate when treated consecutively as they have been by the writer for weeks, that *the action of the electric currents in no wise affects the compensation of the heart muscles, or in other words, they do not depress the heart.* This is a very important observation, and one that is certain to be carefully considered by those who may contemplate the employment of the method. The effects of the treatment on the contrary are beneficial even with the resisting cases, due, probably to the influence upon general metabolism; promoting as it does elimination of the products of metabolism, which are liable to accumulate in old people the subjects of advanced arterio-sclerosis.

*The classification based upon results of treatment* which the writer adopted in a previous paper on the subject* seems to give a practical index as to the prognosis, to be determined from the history or results of treatment for a week or two, it being effective in cases in varying de-

*Treatment of Arteriosclerosis and Hypertension. Journal of Advanced Therapeutics for June, 1909.



grees depending upon the probable extent of the sclerotic process.

Class I. *In the aged and feeble,* with lowered nutrition or resistance, which has arisen from some impairment of digestion, or an intervening nephritis, or other cause, the tension may be low while the sclerosis is far advanced owing to a want of compensation of the feeble heart muscles. Low sphygmomanometric readings with marked sclerosis of the arteries, is an indication of failing compensation, which may also be present with valvular lesions, or in cases in which dilatation is present without hypertrophy (see Class VI). In the investigation of arterial tension, the presence or absence of heart compensation must always be considered.

Class II. *General arterio-sclerosis with persistent high arterial tension,* ranging from 200 to 240 mm. or even more, occurs in those of advanced age, and may be so resistant to administrations of auto-condensation which uniformly lower arterial tension, when above normal in other cases, that no measure of relief may be afforded. In these cases it is probable that the entire arterial system, including the small arteries, are to a marked degree sclerosed. In these cases the impending sequelae cannot be averted, except by an even life free from excitement, and the employment of a non-stimulating diet, by which life may be prolonged.

Class III. *Arterio-sclerosis in most patients at ages from sixty to seventy years* may often at first seem to resist measures which affect high arterial tension, without producing cardiac depression, but yield finally under treatment and are reduced to a degree of hypertension which will avert apoplexy with corresponding improvement in

general health. In these cases in which the reading at the onset is often more than 200 millimeters of mercury, the tension may be scaled down in the course of a month or six weeks by daily or alternate day treatment to 165 to 160 mm. or even in some cases as low as 140 mm., at which the tension may be maintained by regulation of diet and occasional treatment. This class of cases, should not be directed to take active, but moderate exercise. Patients in this class will usually be of advanced arterio-sclerosis with a marked degree of cardiac hypertrophy, but judging from clinical results, it is probable that some of the vessels still respond to the high potential currents which vary vaso-motor conditions without producing heart depression. It might be possible in these cases if daily treatments were administered to bring the blood pressure down to normal—120 mm.—but it would be imprudent to alter the conditions of relation between cardiac hypertrophy and the work demanded in these cases to such a marked degree. On the other hand the effort here should be directed to relieving the heart of excessive labor, and at the same time reduce to a minimum the dangers of apoplexy and nephritis. It is the author's opinion that by judicious watching and management, these cases may be kept at a *status quo* for an indefinite period, probably five to ten years, or even longer in the more favorable cases; this seems to have been demonstrated in some cases. On general principles it is best to maintain the arterial tension in these cases between 140 and 170 mm. with a general possible average of 150 to 155 and without danger in case of an occasional maximum of 180 mm.

Class IV. These cases include those of advancing arterio-sclerosis in mature adults generally at ages rang-



ing from thirty-five to sixty, in which the tension may have scaled to from 150 to 200 mm., associated or not with a commencing interstitial nephritis. Nephritis is often not present in cases having an arterial tension of from 200 to 250 mm. Patients in this class after twelve to fifteen minutes of auto-condensation employing 400 to 500 milli-amperes will show a marked fall in arterial tension averaging ten to fifteen mm. and with frequent treatments given in connection with regulation of diet and exercise will rapidly be reduced to or near normal. In these earlier cases, the cardiac hypertrophy is apt to be marked, but is rarely complicated by dilatation, and the tension may be safely lowered to the high normal—120 mm. and maintained there without danger of producing any subsequent failure of cardiac compensation, but greatly to the relief of the patient.

If nephritis with albumen and casts is present they usually disappear from the urine after treatment for a few weeks, and a general sense of well being replaces the previous feeling of weight and tension. With nephritis it is generally advisable to also employ the static wave current daily, for the purpose of relieving the congestion. An electrode which will cover the region of the kidney should be employed for twenty minutes with a six to ten inch spark-gap preceding the daily auto-condensation treatments. There is probably no more efficient means of overcoming an interstitial or parenchymatous nephritis than the application of the static wave current in this manner. It will be found however, that with the combined use of the wave current with the high frequency current in chronic interstitial nephritis, the reduction of

the blood pressure will be at first less marked, owing to the counter action of the two currents.

Class V. This class is characterized by a condition of hypertension found usually in adults at from twenty-five to sixty-five years of age, in which the sphygmomanometer indicates the presence of a moderate degree of hypertension, ranging from 130 to 145 mm., but who respond promptly to d'Arsonvalization with a fall of arterial tension. In this class are represented the cases which are as a rule incidentally found when under treatment for some other condition, or when examination is made for life insurance. These patients have not generally developed any atheromatous or sclerotic condition of the arteries, but will if hypertension is allowed to persist and increase as it is certain to if neglected. In these cases, the patient may be rendered relatively normal, and with the proper regulation of the diet and exercise, present an uniformly favorable prognosis. There is probably no condition so insidious and unobserved as the steady inroads leading to arterio-sclerosis, and no field to which the physician's timely attention can afford more service to humanity; by correcting the conditions which develop arterial degeneration; thereby saving from pending disaster the individuals included in this class of cases.

Class VI. Adults who have led very active athletic pursuits, comprise this class. They may have developed cardiac hypertrophy from over training on a college team, or as athletes, boxers, or others who have been for long periods under severe training or physical exertion; and have developed a muscular system which has made great demand upon the cardiac muscles. Under such conditions the demands upon the circulation are so great that



the cardiac hypertrophy is associated with dilatation. Probably no class of cardiac affection has received less consideration than this. The recognition of the error of excessive exercise and its consequences are not often enough recognized by those in charge of college athletics.

The management of this class is prophylactic, looking to the consequences after discontinuance of active pursuit and training, when there is certain to follow an atrophy of the cardiac muscles and persistence of the dilatation, that has coincidently occurred, resulting in the serious condition of cardiac dilatation without hypertrophy. In these patients as the atrophy advances, the blood pressure falls and the patient may pass into a hopeless condition or in the less severe cases, exist with sufficient cardiac compensation to enable him to follow a sedentary life, but always with dyspnoea on exertion, and an impending danger of ultimate collapse.

Class VII. Cases of compensatory hypertension due to obstructing parenchymatous nephritis or cirrhosis of the liver, or other conditions demanding compensatory tension, which may be present with or without arterio-sclerosis, usually occur as a temporary condition. In this classification we have included a variety of conditions in which the study and management of hypertension and the allied affections, is of much importance to the practitioner, and of great moment to the patient. In these cases there are three significant indications: (1) to overcome as soon as possible the condition of congestion, particularly as present in the diseases of the liver and kidneys referred to; (2) to improve metabolism and promote elimination by other channels, particularly to assist the elimination by perspiration of the waste products not eliminated by

the impaired kidneys; and (3) to maintain a high arterial tension when it is compensatory.

There is no measure which acts with such potency and certainty in relieving congestion of a *cirrhotic liver* or of an *inflamed kidney* as the static wave current. In the hypertrophic stage of cirrhosis of the liver it is possible by applying a large metal electrode over the distended liver and using a spark-gap long enough to produce decided pulsation and tissue contraction throughout its substance to rapidly reduce the infiltration. In the writer's experience in two cases livers of this sort were reduced to near the rib line, and others very materially reduced with a relative improvement in the physical condition of the patient. This same effect has been obtained by others in reducing enlarged spleens due to malarial infection.

*In parenchymatous nephritis* a metallic electrode six by eight inches in size is placed over the region of both kidneys, which situated as they are just beneath the muscles of the back, are readily affected by the wave current, when employed with a spark-gap varying from six to ten inches, depending upon the thickness of fat overlying the muscles, or the character of the muscular structures themselves. A fortunate coincidence exists in that the wave current does not materially affect to lower arterial tension, and may be applied in these cases with sufficient energy to relieve the infiltration without lowering the compensatory hypertension.

*The effect upon general metabolism* in these cases is to increase the resistance of the cell by improving peripheral nutrition and to promote the elimination of urea through the skin, thereby lessening in parenchymatous nephritis the danger of uremic poisoning. For this purpose the *electric light baths* in which radiant light and heat may be administered with the patient reclining, are probably of first importance, combining as they do the beneficial effects of light and the important effects of heat. *The body dry hot air bath,* in lieu of the properly constructed light bath, would serve very much the same purpose in stimulating perspiration and elimination. Both of the last named measures also stimulate the deep spinal centers of the heart and respiration to greater energy and coincidently relieve them from the toxic influences of the poisonous waste products otherwise retained on account of the impaired function of the kidneys. *The static wave current* as applied for relieving congestion elsewhere also coincidently facilitates general metabolism and elimination. These measures are congeners, cooperating to relieve the system of the poisons which might otherwise overwhelm the organism.



*In order to maintain the compensatory high arterial tension* which is present, in these obstructed conditions, the *auto-condensation method should never be employed lest a fatal relaxation of the arteries lower the blood tension, which is necessary to force the blood through the congested kidney.* To lower arterial tension in parenchymatous nephritis might be fatal. It is then a matter of grave consideration to avoid an error so apt to inadvertently occur, of lowering arterial tension in these patients. It is a fortunate coincidence that the static wave current does not affect blood pressure in these cases; but on the contrary acts to relieve the infiltration which causes the obstruction. *Light baths,* while inducing to a degree superficial arterial relaxation, do not seriously impair the condition of compensatory tension; and are therefore in no

wise contraindicated but very important in the treatment of parenchymatous nephritis.

*The treatment of hypertension*, as will be inferred from the preceding paragraphs, must judiciously employ various measures to meet the varying indications. The procedures indicated for the control or correction of hypertension may be divided into (1) those which act upon the neuro-muscular mechanism, as the d'Arsonval, high frequency and static wave currents, radiant light and heat, hot baths, and carbonic acid baths (the least important); (2) those which increase general metabolism, including the high potential currents, radiant light and heat, exercise and the employment of baths of alternating heat and cold with those who respond; and (3) those which regulate nutrition eliminating from the diet foods, which unassimilated or undigested, furnish culture media for the development of bacteria; the toxines arising from which are the principle factor in causing hypertension.

*The diet regime* employed by the writer consists in the avoidance of red meats, and at the onset all fish and fowl as well, and in advanced cases the avoidance of all animal foods as a permanent diet regime, the abstinence from all alcoholic drinks, and the institution to a considerable degree of a milk diet. The Metchnikoff method of employing milk prepared by the use of lactic acid ferments, meets the indications in some cases, but a larger experience shows that in many cases it proves decidedly objectionable.

Probably the principle of greatest importance in the dietetic regime is the *reduction of the quantity of food taken*. If these patients are put upon half the rations they have been in the habit of consuming, there are but few of them who would lose a pound of weight, indicating



the amount of unabsorbed pabulum remaining to develop an intestinal flora.

*A diminished quantity of food*, together with the rejection of animal proteid, constitutes the most important features of the average diet regime; together with the thorough mastication of food.

*To preserve a condition of health* with normal blood pressure, as a prophylactic measure, the diet must be regulated to the exercise or the individual pays the penalty. When hypertension is already present, exercise is indicated in all conditions, except those included in Classes I and II and VII. Exercise is imperatively indicated when the blood pressure has been reduced to 150 or 160 mm.

*Exercise must be regulated* to the arterial condition, and may be necessarily very moderate in those of Class III in whom an extreme would precipitate too great a rise in arterial tension. In Classes IV and V the degree of hypertension present indicates a rapid tendency to arteriosclerosis, which in Class IV may have developed to a well marked degree; whereas in Class VI exercise is indicated for the purpose of maintaining the cardiac hypertrophy; for if the heart is allowed to atrophy the presence of dilatation without hypertrophy would become a serious impediment, endangering the comfort if not the life of the individual.

*The electrical treatment* of hypertension, except as considered in the cases of compensatory hypertrophy, in which modalities, which lower blood pressure are contraindicated, is the most valuable method of regulation yet discovered. It is possible in all except Classes I and II to lower arterial tension at each administration of from twelve to fifteen minutes to a marked degree—from ten to twenty,

or even thirty mm.—by the auto-condensation method employing 400 to 500 milliamperes as shown by the hot wire meter. This current undoubtedly relaxes or dilates the arterioles. *The modus operandi* of the current in influencing such dilatation is difficult to demonstrate or explain. It is possibly due to the thermic action of the current. The body heat throughout the whole substance of the individual is not comparable to external applications of heat, but to the energetic induction of metabolism and heat production throughout the organism, which is manifested by a general glow or feeling of warmth. It is either this effect, or the effect of high potential currents upon the muscular structures of the arteries, or upon the nervous mechanism which controls the vaso-motor tension.

*The effect of d'Arsonvalization is pronounced,* uniformly lowering the arterial tension when the current is administered to an individual in the classes under consideration, whereas when the blood pressure is normal, there is very little if any change from the usual administration.

*The heart is not depressed* either by the method of auto-condensation or auto-conduction. This may be easily demonstrated as it has been by the writer in numerous instances, when administered on consecutive days to aged patients of Class II who do not respond to treatment with a reduction of blood pressure even when administered daily for months. When administered to these patients there is a sense of relief from dizziness with no lowering of blood pressure, showing conclusively that there is no interference with compensation. Patients on the other hand who are subjects of high arterial tension feel a



marked relief with a sense of lightness following the administration of d'Arsonvalization.

The methods of employing a d'Arsonval current for relieving arterial hypertension as illustrated in Figs. 17 and 45 are the methods by auto-conduction and auto-condensation, both practical and effective measures.

*The auto-condensation method* possesses advantages over the method of auto-conduction, particularly in the con-

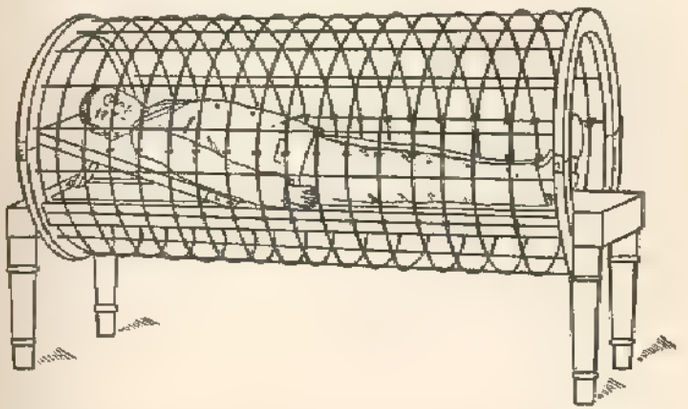

FIG. 45. Arrangement for Auto-Conduction.
The two ends of the solenoid may be connected to the d'Arsonval terminals of apparatus, or they can be connected directly across the outer coatings of the Leyden jars and the Oudin solenoid disconnected.

venience of administration upon a couch and the regulation of dosage with the hot wire meter, by which means it is possible to judge with the same apparatus at least, of the relative effects of current dosage. As stated elsewhere, it is a well-established fact that the variations in the measure of currents by the hot wire meter, from different types of apparatus are considerable, which leads to confusion as to the relative dosage to employ with different types of apparatus.

*The frequency factor* is one that must be understood as increasing the heat production without an actual increase in current flow. The readings of the milliamperemeter vary with the frequency or periodicity without variations in current strength. The writer is in the habit of testing the relative volume of discharge by holding the flat surface between the first and second joints of a finger against the hand of the patient, when if the discharge is of a satisfactory character, for affecting high arterial tension, it will produce a hot discharge about the size of a dime and without a sharp stinging sensation. In some of the types of Tesla apparatus the same discharge in making this test produces a very severe burning sensation. The writer has compared apparatus in which the milliamperemeter has read in some instances from 1200 to 1500 milliamperes with far less discharge, though of the character described, than from other types of apparatus which register from 400 to 500 milliamperes.

*Regardless of meter readings, the test of efficiency of any apparatus will depend upon the average fall of blood pressure in millimeters of mercury.* A properly constituted apparatus and arrangement produces an average fall of from ten to thirty millimeters after each administration. Patients who are treated in this manner under favorable conditions of environment and habit of diet, mark a gain of from three to ten millimeters from day to day when the current is administered daily, which is at the outset necessary in cases in which the tension has been high until such time as the tension is reduced to the desired reading, at which it is intended to attempt to hold the blood pressure, when it is possible to give the treatments on alternate days, or in many cases less frequently, until



the regulation of the diet and exercise of the patient is such that the tension shows less tendency to rise, after which the patient should report at first weekly, and later monthly, in order that by joint observation the conditions may be regulated.

*Every patient who has once developed a hypertension* considerably above normal should have observations made from time to time in order to avoid a repetition of the tendency to re-establishment of a high pressure, and the more pronounced cases should keep themselves constantly under observation in order to keep arrested the tendency which will be constantly present of the arterial tension to again become high.

*The method by auto-conduction* in which the patient is seated within the solenoid, receiving and conducting the lines of electrical energy passing inductively across the field, feels a perceptible glow of warmth. Under these influences the thermic action of the current is extended, and the blood pressure lowered. Here again the indication is that the lowering of blood pressure is to a degree due to the thermic action of the current. The same principle is employed here, as in heating metals to a great heat when placed within small solenoids when larger ampere currents are passing. There is no doubt that the action of this current is fairly uniform upon all parts of the body of the patient; and it may possess an advantage in this respect over the auto-condensation method in that the condenser effects, as shown in Fig. 17, cause the greater condensation of the current to pass through the tissues nearest the condenser plate beneath the cushion. The effect however upon blood pressure, as shown by recent observations, is variable by this method, depending upon the construc-

tion of the solenoid. Those of many turns of fine wire tend to raise instead of lowering arterial tension.

*That the nutritional effect of auto-conduction* is remarkable, was demonstrated by Dr. Herdman of Ann Arbor by placing a number of young rabbits of a litter for some hours daily within a solenoid they being kept otherwise under the same conditions as the control rabbits, which were not so treated. The former made a more thrifty growth and gained in weight and size over the controls.

*A meter for showing the relative strength of current* passing through the patient taking auto-conduction has been designed by Denoyes of France.

*Another method of employing auto-conduction* may be employed with the static machine. The patient is placed upon a chair upon the insulated platform and put in a reclining position and a half cage is drawn down just far enough away from every part of the patient not to permit sparks to pass from his body to the grounded cage. A connection is made to the platform with the shepherd's crook, or a chain or rod connecting the platform with the positive side of the machine. The negative side is then grounded, and a spark two inches in length is permitted to discharge between the pole pieces, the machine running at a rapid rate of speed. This method is very effective in lowering blood pressure. In this instance however, the thermic effect is less perceptible than with the other methods, and lends the strongest argument to a theory that the action in lowering blood pressure is upon the neuromuscular mechanism of a sort peculiar to the high potential electrical currents, and not to heat production.

## CHAPTER V

### DISEASES OF THE NERVOUS SYSTEM

DISEASES of the nervous system considered from the therapeutic point of view may be classified as (1) those of central origin associated with lesions of the brain or spinal cord; as (2) peripheral inflammatory lesions affecting the nerve trunks; and (3) reflex or functional neuroses having their origin usually associated with lesions or disturbances of the sympathetic system; and presenting mental or psychic symptoms referrable to the central nervous system.

*Inflammatory affections* are in most cases the cause of diseases of the nervous system as of other parts of the body. These arise, likewise, from infection, toxemia, mechanical injury, and errors of metabolism.

*In the treatment of diseases of the central nervous* system, the therapeutic indications depend upon the relief as far as possible of central lesions and the systematic treatment of peripheral conditions for the purpose of maintaining peripheral metabolism. In these cases nutrition and function may be a long time maintained by peripheral stimulation. *Lesions of the brain* are practically beyond relief from the applications of high potential currents, except in so far as blood pressure may be controlled and central lesions be reflexly influenced and nutrition improved.

*Mental derangements* cannot in all cases be referred to

lesions of the central nervous system. Only those cases in which an active lesion is present can be classified under this head; the others will be treated as reflex or functional neuroses. It has been claimed by some, that in cases of cerebral hemorrhage, by passing a mild galvanic current through the base of the brain, it was possible to hasten the absorption of the clot. This may be so, but it cannot be generally accepted owing to the mild currents which must be employed in these cases, such as could not affect the cerebellar portions of the brain.

*The treatment of apoplexy* may be prophylactic when a condition of high blood pressure with a pending crisis from advanced arterio-sclerosis is early enough discovered. Such cases under careful observation and regulated diet, with the blood pressure kept under control as described in the previous chapter, can be kept for many years from the danger of apoplexy, even after a first attack. When apoplexy has occurred, there is no measure that will accomplish so much as the combined effects of body administrations of radiant light and heat and d'Arsonvalization in facilitating a rapid absorption by the induction of arterial dilatation, thereby increasing the circulation and metabolism in the brain, as of the rest of the system.

*The inroads of degeneration of the brain cells,* associated with advancing arterio-sclerosis, may likewise be impeded, and nutrition preserved by the employment of d'Arsonvalization by the auto-condensation and auto-conduction methods. There can be no contra-indications for the employment of these in cerebral cases, unless for some reason a high blood pressure due to compression of the brain cells may be compensatory.



*In tumors of the brain,* the effects of mechanical injury, syphilitic lesions, or from other causes, it is doubtful if external treatment is of any avail, as the bony capsule makes it impossible to produce any direct physical effect upon the structures of the brain.

*In diseases of the spinal cord,* the conditions are more favorable to treatment than of the brain. Incased in a bony canal, and with the ligaments surrounding the joints of the vertebra, the cord is not easy of access by low potential currents except through reflex stimulation. It is possible however to locally affect these structures by the high potential currents, particularly the static wave current and static sparks. This has been demonstrated in the successful treatment of conditions the result of mechanical injury, affecting the cord and surrounding capsule. No lesion is more intractable to the older methods of treatment than spinal arthritis and tubercular lesions both of which respond to the high potential currents; the former by the application of the static wave current and static sparks, and the latter by the direct d'Arsonval in accordance with the general principles of treatment of the two different types of inflammation as considered. In lesions of the cord associated with mechanical injuries, except those in which actual fracture of the vertebra has taken place, these modalities are prompt and effective, as indicated by the following case:

Mr. M., injured in a head-on collision in a railroad accident, sustained a concussion at the base of the brain with a region of swelling and tenderness over the first, second, and third cervical vertebra, and a spinal injury at the junction of the eleventh and twelfth dorsal. Eight days after the accident the patient had made no improvement

when he came under the writer's observation. The left side was partly paralyzed, the gait very labored and shuffling, with complete inability to raise the right hand. The left side of the body was in a state of choreic movement, including the arm, neck and left leg. His reflexes on that side were all exaggerated; so much so that a tap on the patellar tendon would throw the patient into convulsions. He was treated with the static wave current, a narrow metal electrode being placed over the upper cervical region and extending to the middle of the dorsal for twenty minutes. A spark-gap nine to twelve inches in length was employed. This was followed by a second administration to the lower dorsal and lumbar region of the vertebral column. This administration was given twice daily with marked improvement from the first; and at the end of ten days he could use his paralyzed arm, the choreic movements of the other side had almost entirely ceased, and he was able to go about town. At the end of three months every evidence of the affection had disappeared. The gravity of the condition was apparent from the fact that the railroad settled his case early on the advice of their physician, paying him upwards of $14,000. The same result has been obtained in the treatment of all similar cases of arthritis of the spinal column, including the lumbar sprains. These results demonstrate the capacity of the current to penetrate to the deep spinal centers.

*In anterior poliomyelitis* applications of the wave current to the spine in the manner described have been followed in all early cases by phenomenal results. The improvement in all early cases is pronounced; while in older cases the improvement is often marked but the prognosis



is not so good from the fact that the lesion has already destroyed many of the spinal centers.

*The indications for treatment* in anterior poliomyelitis are to produce an active metabolism in the involved section of the cord in order to promote the elimination of the congestion or infiltration which has occurred incident to the local lesions whatever the origin. The latest investigations of Flexner and his associates would indicate that the disease is of infectious origin. If so, the damage has been done when the paralysis occurs, and the infiltration will persist even after the removal of the cause, which is active as indicated by the fever, rarely present for more than two or three days. The effect of the process, however—the infiltration producing pressure—will persist unless some means is employed to remove it.

*For treatment* during the acute stage, probably no agent is more beneficial than prolonged applications of radiant light and heat, which will produce a general hyperemia of the skin of the whole body, thereby drawing away much of the fluids from the region of probable congestion, and at the same time eliminating the toxic products of the infection by the channel of the perspiration, which is induced by the application.

The application of radiant light and heat should be followed after the first forty-eight hours, at least, by the daily application of the static wave current for twenty minutes with a narrow electrode approximately one inch in width over the region of the cord affected. In cases involving the whole length of the cord from the upper cervical to the lower lumbar region, the mistake liable to be made by operators is due to a disposition to use too short a spark-gap with the static wave current, whereas, even

with small children, the spark-gap should be of considerable length—six to ten inches. The size of the terminal balls of the discharging rods, which allow a greater or less degree of charge, should be regulated to the size or age of the individual. These should be varied from ½ to 1¼ inches in diameter according to the age or muscular development of the patient. It must always be appreciated by the operator that the current employed is of such small amperage and so widely diffused throughout the body of the patient in passing to and from the periphery, that the element of danger is no greater than from a shower bath; and also, that the greatest current condensation associated with muscular responses is immediately beneath the surface of the electrode, causing the influence to be very active upon the structures of the cord.

*The effects of the current* under these conditions as evidenced by the prompt tendency to recover motor functions, is marked and positive usually from the first administration. Even in cases of relatively longer standing, this is noticed, though the extent of recovery is less in proportion as the condition has been present for a long time. If for any reason one limb or part persists in a condition of disability, greater energy should be employed over the corresponding region; because greater hemorrhage and crippling of cells in their function has taken place in the corresponding part of the cord.

In order to avoid atrophy, which is so marked and pathognomonic of lesions, affecting the portion of the cord involved, it is important that the peripheral nutrition of the paralyzed muscles be maintained, and in the later cases that they be stimulated. It has been for a long time the practice of the profession to employ the constant and



induced currents over the affected muscles. After an extended experience, however, the author has demonstrated the greater benefits to be derived from the employment of *radiant light and heat and interrupted mechanical vibration*, gently, but actively employed over these muscles, at first daily, and later on alternate days. *Massage* may be employed at intervals but is undoubtedly of less efficiency than the more practical and energetic application of mechanical vibration, employing a small flat disc applicator to all the muscles of the affected parts. It is possible by these means to prevent atrophy in the limb when employed from the first for months, though paralysis may have persisted. They are therefore valuable for maintaining the muscles and other parts, pending the relief of the corresponding centers in the cord.

*The prognosis* under routine treatment is relative to the promptness with which it is instituted, few cases failing to make complete or prompt recovery, when the treatment described is instituted early, and later it is relative to the extent of damage done.

*In tabes dorsalis* the lesion is a progressive sclerosis due to an inflammatory process, the exact character of the origin of which has not been discovered, though too often attributed to syphilis. Fully fifty per cent. of the author's cases have given an unquestioned negative diagnosis as to syphilitic origin, though the Wassermann reaction of recent institution had not been employed to confirm the diagnosis. So many cases have given instead a history of spinal concussion that it is hopeful that this method of diagnosis will eventually deny the statement, until recently so generally proclaimed by neurologists,

that it is invariably of syphilitic origin—an imputation unjust to the innocent.

*The indications for treatment of tabes dorsalis* are first of all practically directed to the treatment of the cord lesion as in anterior poliomyelitis for which the static current is employed. The static wave current with a long narrow electrode over the spine employing a long spark-gap for twenty minutes is remarkably effective in relieving the pain of tabes, and, in many cases, eventually arrests the process in the cord.

*The conditions of muscular contraction* particularly involving the lower extremities and back in tabes, are also relieved by the static wave current and sparks in conjunction with applications of mechanical vibration to the motor points and tense muscles, wherever found, in accordance with the principles of relieving muscular spasm with these modalities. This relief however is only temporary unless the central lesion is favorably affected.

*Areas of anesthesia,* which are usually marked in the extremities below the knees, particularly in the leg, are best diagnosed, both as to extent and degree, by the passage of the brass ball electrode over the clothing. The pear-shaped sparking ball was suggested and designed by the writer for the treatment of these cases. Friction sparks applied in this manner will elicit the extent and degree of anesthesia; and when applied systematically for the requisite time by passing the ball over the clothing, it is surprising how much the sensibility of the part is restored by the application. Likewise the application of short sparks to the soles of the feet is capable of increasing the sensibility in the nerves of the integument here also. Applied in this manner during the course of treatment,



there will be a marked diminution of anesthesia. Some attribute this to the effect upon end neurons, and others as due to the ingoing impression conveyed to the central neurons, by which their function is increased. Be this as it may, the employment of friction sparks over the anesthetic areas in this way is remarkably effective in assisting to relieve the anesthesia.

*The pains of tabes* are, as a rule, diminished during a course of treatment by the static wave current, and are finally entirely removed for long periods in cases who attend strictly to treatment. During the paroxysms the pain is remarkably relieved by showers of short sparks applied directly over the seat of pain. It is often possible to completely arrest the terrible pains of tabes by such severe applications of short sparks to the painful areas.

*The girdle sensation* may persist after all other symptoms have disappeared, and is the most stubborn symptom to treat, though static sparks and mechanical vibration over the posterior roots and the contracted muscles do influence to a degree this symptom.

*The tabetic or ataxic walk* is greatly relieved by the removal of tension from the contracted muscles, and the relief of anesthesia in the feet. While co-ordination may remain much impaired, education in the use of the muscles —teaching the patient to walk in a normal manner under the exercise of will, together with the institution of daily systematic exercise in the performance of the necessary movements, together with the realization of the most important rule of Fraenkel, that, "the individual walks with his body, and not with his limbs," in other words, that the carriage of the body forward is what causes the limbs to move, to maintain the equipoise, giving a forward impetus

to the movement of the whole. It is unreasonable to suppose that training in walking can accomplish any permanent benefit in the progress if the pathological process is not arrested.

*The Argyll Robertson pupil and the patellar reflexes* are not apt to be restored even in the early cases of tabes, though the progress of the lesion may undoubtedly be arrested.

*A dilated bladder* may be remarkably improved; and the vesical symptoms almost uniformly relieved by rectal treatment, or the employment of an abdominal electrode above the pubes. The action of the wave current in these cases is to throw the parts into active exercise, that is, stimulating the action of muscular fibres of the parts so treated, and increasing tone, metabolism and nutrition.

*The prognosis in tabes,* under this plan of treatment will vary very largely in different cases and must depend upon the results of treatment. A few cases may not respond to be materially benefited though in most cases an arrest will be instituted. In fully seventy-five per cent. of the cases in the writer's experience, the improvement is marked from the first, and in at least fifty per cent. an arrest of the progress of the disease is effected. The length of time required to effect these results will vary in different cases. The patient, however, from the beginning of treatment should be instructed to expect that it will require a long course of treatment to effect satisfactory results in these cases. Daily treatments should be given, or at least six times weekly during the first two or three weeks, followed by alternate day treatments and less frequent as the progress will indicate, for at least a year. Patients should be kept under observation for many



years, applying for relief promptly whenever there is any recurrence of active symptoms.

No plan of treatment offers so much for these sufferers as the combined employment of static electricity and mechanical vibration, together with the institution of systematic exercise, the employment of which, without treatment directed to the lesion, is irrational.

*In spastic paraplegia,* it is possible to temporarily arrest the annoying symptoms of muscular contraction and spasmodic movement and improve the walk; but it is doubtful whether more than a temporary arrestment of the process is accomplished, though a temporary arrest has been demonstrated by the writer. The static wave current is applied in these cases to the part of the spine in which the lesion is demonstrated; usually in the lower extremities. The disturbing vesical irritation is likewise materially benefited by the same treatment.

*In lateral sclerosis in the early stages, and transverse myelitis,* the rational treatment is the employment of the static wave current as described in other cord lesions as it has shown marked beneficial results in the treatment of the writer's cases.

*In syringomyelia* which is not, we believe, so often an incurable condition as has been supposed, if timely treatment is instituted the local induration of the cord substance will be relieved and the degeneration arrested. One case referred to the writer which had been under observation in one of the leading college clinics of the city, with a progressive loss of power in one forearm for three years under treatment, after having the static wave current applied over the spine, and the application of mechanical vibration and light to the anesthetic areas, was

completely arrested and followed by restoration to normal tactile sensibility of nearly all of the anesthetic area which included most of the surface of the forearm; only one very small area persisting. The atrophy which had begun in the hand, involving the thumb muscles, ceased to progress, and after an elapse of three years there was no recurrence of the symptoms. It is probable that similar treatment in other cases will be followed by similar results.

*In chorea major* the conditions of general hyperasthesia and reflex irritability, emanating probably from an active hyperemia, in the cord, has been promptly relieved by the author, by the application of static insulation with a long spinal electrode extending from the dorsal to the upper cervical region—the machine running at a rapid rate with the balls so widely separated that no spark can discharge across the gap, together with the peripheral application of radiant light and heat to the whole body to the extent of producing a general hyperemia.

*Pachymeningitis,* involving the meninges of the cord, and other hyperemic conditions, as those associated with hysteria, are rationally treated and usually promptly benefited by the application of the static wave current over the cord as described in the treatment of other cord affections.

The treatment of these conditions is rational and we are glad to say effective in so many of these otherwise intractable conditions, that they are cordially recommended to the reader. To be effective, however, it must be borne in mind that a long spark gap is required when the wave current is applied to the cord over the vertebral column, regulated, however, to the physical conditions of the patient; with the average adult employing terminal



balls on the discharging rods one and one-fourth inches in diameter. As in all inflammatory conditions the wave current is administered for twenty minutes at each treatment.

*The peripheral affections of the nervous system* include those associated with disturbances of circulation with the production of pain or other disturbances of sensation; most of the latter of which however are of central origin. Of these the different types of neuritis are of greatest significance.

*Neuritis* is usually designated according to location; and very often by misnomer is termed *neuralgia;* as neuritis of the face is very frequently called facial neuralgia, and also of the sciatic, sciatic neuralgia. Until the problem of treating neuritis has become a relatively simple one, and the lesion may now be readily and systematically located, it is easy to understand how the term neuralgia came into medical literature. At best the term is an expression of indifference to diagnosis; for neuralgia can never be recognized as other than a symptom.

*The therapeutics of neuritis* recognizes a local inflammatory process with the indication for treatment the same as in other non-infected inflammatory processes,—the dispersion of infiltration with the relief of pressure and pain.

*The diagnosis of neuritis,* or localization of the seat of the lesion, is easily effected with the static wave current applied through the medium of a flexible metal electrode directly over a suspected site; when if present, it elicits a degree of pain which is diagnostic in comparison with the effect upon the normal tissues. The pain arising from causing contraction of tense muscles by the wave current, may very often be mistaken for the pain due to a

lesion; because when muscular contraction exists, the intense stimulus increasing the contraction, will cause pain until the muscles gradually relax. This relaxation however will be effected within the first five or ten minutes, when if the spark-gap is lengthened considerable no more pain, is produced; whereas over the lesion of neuritis, during the first administrations, the pain will during the seance persist with the gradual lengthening of the spark-gap for the full twenty minutes of the treatment.

*The prognosis* as to time necessary to cure neuritis will depend upon the length of time that the process of exudation and infiltration has been present. In long standing cases the exudation often becomes organized, and the nerve adherent to the surrounding tissues. In these cases the impairment of the nutrition of the limb, and persistent disturbance on use on locomotion of the limb will be marked and the length of time necessary to effect the restitution of the parts supplied by the nerve, will depend upon the region, extent, and character of the local lesion. In cases in which the lesion is within the pelvis, and above the sacro-iliac-synchondrosis, the prognosis will be uniformly bad; because it will not often be possible to affect an induration so remotely situated.

There are certain places where, on account of exposure to pressure, violent muscular action and external violence, neuritis is liable to occur. The most common sites are where the sciatic nerve passes through the sacro-sciatic notch beneath the pyraformus muscle; where the crural emerges; where the large nerve trunks cross the sacro-iliac-synchondrosis; where the musculo-spiral and circumflex emerge beneath the teres minor; where the supra-scapular passes out from beneath the trapezius, and through



the supra-spinatous fossa of the scapula; where the inferior dental passes into the canal in the inferior maxillary bone; and where the superior maxillary branch of the fifth nerve passes through the infra orbital foramen.

When a lesion is located at these points, the origin may be attributed as a rule to mechanical causes and exposure.

*In herpes zoster* and intercostal neuritis the lesion will generally be located where the posterior roots emerge from the spinal column.

*Other causes than mechanical injury or exposure* are from toxemia or local infection, which cases respond to treatment by intestinal antiseptics. The cases occurring, however, at the sites enumerated may but rarely be attributed to toxemia or infection.

*The treatment of neuritis,* either of mechanical or infectious origin, is practically the same, except that in the early stages in patients in which a toxemia may be suspected, the use of aspirin or salicylates may prove beneficial. Exceptional cases may recover spontaneously; but, as a rule, no class of conditions is more stubborn or resisting to other methods of treatment.

The usual methods employed at the present time by physicians and neurologists not familiar with more practical methods are to put the patient to bed with fixation splints, nerve stretching and surgical operations, Turkish baths, and massage, and treatment at various health resorts and spas, by similar measures. These have been followed quite uniformly with unfavorable results, as evidenced by the number of cases that are uncured by them.

*The static wave current* and static sparks are so uniformly successful in the treatment of these cases, that it is to be deplored that so many are ignorant of that method

of treatment. In all cases in which an electrode can be placed immediately over the site of the lesion, the application is both diagnostic and curative, if used with the proper energy in connection with direct applications of static sparks to the lesion. By these means it is possible to remove the infiltration surrounding the nerve, and by daily applications to effect a complete relief, by the removal of the pressure upon the nerve, finally restoring the nerve to a normal condition. In the early cases, within the first two weeks, the results of treatment are very prompt and effective. It is possible in any accessible neuritis before adhesions have occurred, or tissue organization to effect a cure in a few days. The writer has verified this in seventy cases of acute sciatica, all of which have been cured within ten days. The same is true of brachial neuritis, facial neuritis, and herpes zoster.

*The technique employed* in the treatment of these cases is the application of the static wave current with a flexible metal electrode applied directly over the site of the lesion. A spark-gap which produces a bearable pain is employed from the outset, and gradually lengthened during the twenty minutes allowed for this application. If at the end of the wave current administration there are muscular contractions which limit the motion, or cause pain upon movement of the affected limb or part, the application of sparks to all such muscles is indicated, the patient moving the arm or leg in different positions, sparking the muscles where tension is present until considerably, if not entirely relieved, which will be followed by a general feeling of lightness and mobility and the patient will be able to continue his work during the course of treatment.



*In tic douloureux* or *facial neuritis* the application of the wave current should be followed by the static brush discharge and static sparks, making a thorough application over the whole surface; also in supra-orbital neuritis, or herpes of the scalp. If portions of the nerve are involved that can be best reached within the mouth, as at the inner surface of the inferior maxillary bone, or below the antrum, the use of the direct vacuum tube current applied internally with the electrode shown in Fig. 46, is very efficient.

*In herpes zoster* the application of radiant light and heat to the extent of inducing active hyperemia over the affected area, followed by applications of deep mechanical vibration over the posterior nerve roots, the wave current

Fig. 46. Vacuum Electrode Designed for Treatment of Tongue or Tonsil.

over the unerupted patches and the brush discharge over the herpetic patches give prompt and almost complete relief, readily curing this otherwise intractable affection.

There has probably been no advance made in therapeutics which is of more striking contrast to the old methods than the advanced methods of treating neuritis.

*The functional neuroses* according to most neurologists are largely of psychic origin, and are often designated by them as psychopathic neuroses. There are many reasons to believe that very few if any of the so-called psychopathic neuroses are purely the result of mental environment, but in most cases are associated with a physical inflammatory cause. The fact that the neurologists have

drifted into, what it may seem presumptuous to call, a mistaken conception, is probably due to the fact that it has been so long that the remedies have been ineffective, which have been employed to remove the physical conditions which are the cause. This has been clearly demonstrated in many instances in cases who have been in the hands of these gentlemen—cases which when they receive curative treatment directed to some part of the organism, particularly to the pelvic organs, are relieved of the psychic phenomena.

A well known business man, a former patient of one of the best known New York neurologists had for three years been under treatment for neurasthenia. He came under the writer's observation and was treated under his direction for prostatitis associated with impotency, and made a complete recovery in a few weeks.

Another case, referred by a neurologist, was one of pustular acne which had produced a profound degree of mental depression on account of the disfigurement. The condition was cured and the psychic phase disappeared. In the former case the lesion produced a functional derangement, and in the latter the impressions were psychic.

In the author's experience, fully twenty-five per cent. of his cases of prostatitis, now numbering more than 140 cases, have been subjects of neurasthenia, and were cured of both the prostatic and psychopathic derangement by treatment of the local condition.

The author was first impressed with these views seven years since from the treatment of hysteria in a female patient, when by employing the static wave current with a metal electrode placed in the rectum in the treatment of a case of constipation, a hysteria for which the patient



had been referred to the writer for electrical treatment, was promptly cured, coincident with the relief of the dysmenorrhea, which had persisted for upwards of thirteen years. This result demonstrated two important truths: (1) the efficiency of the method in the treatment of dysmenorrhea; and (2) that with the cure of dysmenorrhea there will often be prompt subsidence of the hysterical symptoms. This has been the result in the treatment of a large number of similar cases of neurasthenia and hysteria, from the treatment of some pelvic conditions, particularly in cases of prostatis and uterine congestion. These cases are cured of the psychic manifestations when the local troubles are relieved except when the psychic condition has been present for a long time; in such cases long present impressions are apt to be fixed.

*The attitude of the neurologists* on this subject can probably be attributed to the fact that the gynecologists have uniformly resorted to surgery in the treatment of these pelvic conditions. Surgical methods while invaluable in selected cases either dismember and render the hysteria or neurasthenia worse, or prove of but temporary avail in many cases, particularly in the cases of simple congestion of the uterus, and prostate gland. The removal of either the prostate gland or the uterus is known often to produce serious mental derangement. Curettage, prostatic massage, and rectal or vaginal injections of hot water are uniformly ineffective in relieving to a sufficient degree either uterine or prostatic congestion. Unless the neurologists are willing to investigate the subject from this point of view, it will remain for the general practitioners or gynecologists or genito-urinary specialists who are familiar with efficient means of relieving pelvic congestion, to dem-

onstrate the correct status of the so-called, functional neuroses.

Another class of affections which is liable to lead to neurasthenic symptoms are the derangements of the stomach and alimentary canal; often from hyperchlorhydria, and conditions associated with constipation with intestinal putrefaction and toxemia.

There are also many cases in which an inherited physical status and unsuitable environment may develop a set of psychopathic symptoms. To presume, however, that even these cases if placed under proper conditions of environment and hygiene, in happy home surroundings, fulfilling the natural functions of existence, are certain to be subjects of neurasthenia and hysteria without other physical cause, is contrary to experience; for when under adverse conditions of birth, the resulting neuroses may generally be averted by happy surroundings and judicious discipline. To consign cases of functional neuroses to the Christian scientists, or other psychic healers, without directing treatment largely to physical conditions, would be undoubtedly to compromise the best interest and future health and happiness of the individual. To decry the employment of auto-suggestion is far from the author's intent, but to substitute it for physical treatment when actual physical derangements exist is bad practice.

*The proper management of these cases* employs conjointly a healthy suggestive treatment for the purpose of exerting the proper psychic influence upon the mind, with the rational treatment directed to the relief of every physical condition discovered.

*The diseases designated as functional neuroses* include



the symptoms complex known as *neurasthenia, hysteria, hypochondriasis, functional epilepsy,* and *chorea.*

*The effort to differentiate* the symptoms which shall make a clinical picture of the first three conditions, is quite difficult; and we believe is not in accord with what must be eventually recognized as a varying effect or reflex which may affect different individuals in different ways, even when causes are much the same. In other words, the differential difference between hysteria and neurasthenia which was once stated by Gowers to be one of sex, at the present time is discountenanced by the modern school of neurologists; though it may have embraced more of truth than is now acknowledged. Freud has come nearer to what seems to the writer to be the correct understanding of the relation of the sex problem to functional neuroses than his contemporaries. The sexual organs are so closely knitted in their functions and nerve supply with the sympathetic nervous system and with the train of reflexes that are traceable through the ramifications of the sympathetic nerve, that it is not difficult to recognize a chain of relations, which constitute the symptoms complex of these neuroses.

*The treatment of functional neuroses,* as suggested, should be directed to the treatment of the symptoms complex. There are very few of these cases which do not indicate a large measure of perversion in all of the nutritive as well as sexual functions. The secretions including the skin and alimentary secretion are inactive, the bowels are as a rule constipated, and most of the cases are sterile or impotent. That the treatment of these patients cannot be effective by one means of treatment, is self-evident, and the absurdity of drug treatment has been likewise demon-

strated by the general failure to cure them by these means. Radiant light and heat and mechanical vibration as indicated; d'Arsonvalization for the treatment of hypertension when present and the static and high frequency currents in the treatment of the two types of pelvic inflammation; simple and infected, each plays an important role when indicated. Regulate the rational indications to each individual case, including in addition to the means enumerated the systematic regulation of diet, exercise and environment. It is impossible to expect to relieve these patients by any one set of measures; because each case presents in the symptoms complex, varying conditions requiring individual treatment by those who are familiar both with the symptoms and methods of treatment to be employed.

*Under a rational regime, the prognosis* is good in early cases, and always relative to the effect that the condition has had upon the mentality of the individual. In long standing cases it cannot be expected to restore to normal a depraved or perverted mentality, the results of a cumulative process of abnormality or perversion. In all cases there will be improvement, and in cases of but a few years' standing the results are uniformly good.

*Functional epilepsy* or epileptiform attacks of reflex not central origin, are apt to arise from overfeeding particularly with excess of meat diet which is improperly masticated. Some cases however in young children of highly nervous organization, may have the condition aggravated by various local conditions of the genitals, or of the mucous cavities as adenoids, and in others it may be associated with eye strain.

*The indication in these patients* is to remove every cause of reflex irritation, and establish the normal functions in



every part of the organism, together with restriction in the matter of foods as to quality and quantity. Meat should be entirely omitted in most cases.

*Treatment:*—The employment in conjunction with regulation of diet and habits of the static wave current, radiant light and heat and mechanical vibration is indicated for relief of conditions to which they are adapted. The static wave current should be employed daily in these cases, preferably over the abdomen, with the prolonged application of radiant light and heat to the extent of inducing hyperemia to the trunk of the body, with the additional application of mechanical vibration to the spine and for the relief of constipation or any other condition to which such application is adapted.

*Chorea* arises from practically the same causes as functional epilepsy and the indications are the restoration of every impaired physical function and corrections under practically the same principles as those suggested in the treatment of epilepsy. The static wave current, however, should not be applied in these cases; but a spinal electrode should be placed directly over the cord, and the machine run rapidly with the balls of the discharging rods widely separated in order that no spark will discharge across the gap; in other words, the administration of static insulation through the medium of a long spinal electrode. A prolonged application of radiant light and heat to the trunk should precede the static treatment. There should also be restraint in matters of diet, and insistence upon an out-of-door life, away from school or other confinement. Under such management the prognosis is good.

The following case will illustrate the method of managing these cases:

M. L. Child, 11 years of age, had suffered from chorea with constantly increasing convulsive movement for three months. When brought for treatment the child was in a condition of general convulsion with a temperature of 101° F. It was with difficulty that she could be kept upon the table or chair, owing to constant involuntary movements of the extremities. The knuckles of both hands were inflamed from constant bruising as she threw the arms about and also the ankles of both feet. The choreic movements involved the face as well as the extremities to the extent that it was with great difficulty that the child could drink or be fed.

The treatment consisted of long applications of radiant light and heat from a 500 c. p. lamp, over the front and back of the trunk and extremities of the child, until well-marked hyperemia was effected particularly marked over the trunk. This administration required practically from forty-five minutes to one hour. The child was then placed on the static chair lying at full length and a narrow electrode was placed over the spine extending from the sacrum to the hair line on the back of the neck. Sheets were placed across the abdomen and extremities and tied beneath the chair, to hold the child in position. If the wave current is administered with a discharging spark, the noise causes an increase of convulsive movements in these patients. Accordingly the current was administered with the terminal balls of a machine having sixteen revolving plates, widely separated and running at a speed of about 200 revolutions per minute, for twenty minutes. Improvement began at the outset, and in eight days the child, whom it was necessary at first to bring in a cab,



was able to come to the office by the surface cars, walking to the office, and in three weeks was discharged.

In addition to the electrical treatment, cold packs were given daily for the first week or until there was no rise in temperature, when hot packs were substituted. In three weeks this child was practically well, and has remained so for one year.

She had been on the use of Fowler's solution of arsenic in large doses from the first appearance of the symptoms, without apparent relief. This treatment was not discontinued during the treatment instituted by the writer; but the promptness with which the symptoms disappeared as soon as the physical treatment was begun, in a case which had been growing progressively worse to the time she came under observation, was evidence of the efficiency of the method of treatment adopted.

The theory of the treatment is the derivative effect and increased metabolism and elimination induced by applications of radiant light and heat, together with effects of the static current upon metabolism, and upon the cord condition. The regulation of diet, which should always be limited, in quantity and kind, to the physical demands of growth and nutrition, by controlling the tendency to overfeeding relieves or prevents the consequent auto-intoxication.

## CHAPTER VI

### THERAPEUTICS IN NON-INFECTED INFLAMMATION

THE careful consideration of the principles and the *modus operandi* of the treatment of inflammation is given in Chapter II of this section. The principles employed in the treatment of every non-infected inflammation is practically the same, except that special devices or electrodes are employed as adapted to inflammatory conditions of the various parts of the body.

*The resolution of stasis or the dissolution of induration,* occurring with an inflammatory process, as previously stated, is the indication in all conditions of simple inflammation. This, with the relief of resulting symptoms of muscular tension or contraction, and the restoration of metabolism, comprise the indications.

The author's life work has been largely identified with the investigation and promulgation of the principles of treating inflammatory processes by the employment of means which would affect the resolution of induration always present with inflammation, and the cause of its persistence except where infection is present. This has been clearly shown in numerous monographs and works published, and verified in the experience of all who have recognized the principles and employed them intelligently. It has been clearly demonstrated in the author's experience that *internal* or *external* applications of vibration or massage in acute inflammatory processes aggravates





the condition. This is well illustrated by the failure from the treatment of sprains and inflammation of the prostate gland by massage. It requires a different sort of tissue activity than that transmitted by vibration or friction to effectually relieve local stasis or infiltration when once established. Those measures will often relieve the resulting muscular tension, thereby affording relief from pressure on the contiguous joint surfaces; but not the induration.

*It is the intrinsic activity,* the activity of the parts indurated, particularly the diffuse contraction at a rate approximating 120 per minute alternating with periods of release or rest of the tissues so involved. This will effect the drainage or elimination of foreign matter from the intercellular spaces. These results cannot be effected by currents which stimulate muscular contraction through stimulation of motor points as is done with the constant and interrupted current, but to be effective require direct application to the muscle cells of the tissues involved. As has been so often stated, this cannot be accomplished so well with any other electric current as with the high potential static modalities; particularly the static wave current, the static sparks, the static brush discharge and the direct vacuum tube current.

These modalities induce effects which have never been duplicated nor can be with currents of low potential or the currents from a Ruhmkorff coil or Tesla apparatus. In other words, *the treatment of uninfected inflammation for removing infiltration must be recognized as the field of the static currents; currents which induce diffuse protoplasmic contraction.* The contractions induced by other modalities is very superficial and ineffective as compared

to the effects of the static modalities which can be regulated to a nicety to the requirement of every condition from the intense or powerful effects necessary to affect the structures of the hip joint and gluteal regions to the gentle administrations to the eye.

The results obtained by the institution of methods of treatment adopted along these lines has been so revolutionary that medical conservatism is always inclined to doubt the possibility of the things accomplished by those who employ the requisite technique.

Treatment of the class of conditions under consideration, may be divided into (1) the types of arthritis, (2) pelvic inflammations, (3) congestions and atony of the abdominal organs, and (4) other inflammations, neuritis having been treated in the chapter devoted to the diseases of the nervous system.

*A sprained ankle* offers one of the best examples for demonstrating the results of the treatment and of the success of the principles of treatment under consideration; because here we have to deal with conditions not complicated by the uncertain elements present in many types of arthritis. The following case will illustrate the facility with which these cases are treated by the static currents.

Miss W., a student of Dr. Savage's Normal School of Physical Education, while exercising in the gymnasium, sustained a severe sprain of the right ankle. She was referred to the author for a diagnosis of a possible fracture of the lower end of the fibula. It was about thirty-six hours after the accident; and the limb was very much swollen and so painful on movement that the patient would permit no manipulation whatever. The x-ray disclosed a normal condition of the bones. In reply to the question "Is there anything else you would like me to do?" the answer was made by the accompanying physician, "Well, what can you do?" The writer persisted in requesting to know what was desired, when the doctor said they wished to have her ready for active exercise in twenty days. When the author replied that she could be ready in ten days, the answer came "Let us see how you do it." The following treatment was employed. The patient was seated upon the insulated platform and soft metal, twenty-two B. and S. gauge composition, was carefully moulded over the swollen parts of the foot, and the wave current administered for twenty minutes. Following this the static brush discharge was applied over the swollen and infiltrated area, when the doctor remarked "The swelling is going out." The whole indurated field became softened in twenty or thirty minutes application of this modality. The static sparks were then applied with the spark director below and around the internal and external malleolus, and over the anterior and posterior extensors and flexors of the foot, all of which were in a state of tension.



When the patient came into the office her foot was strapped with adhesive strips. These were removed and not replaced. The patient went from the office, and down the steps with the crutches in her hands, and said her foot hurt her very little. The next day she returned walking, but with her crutches in her hands, lest she might need them. She was so much relieved by the second treatment, that the following day she returned without the crutches, and within ten days she was able to resume her usual gymnasium work. This case was complicated by a sciatic

neuritis involving the nerve both at the sacro-sciatic notch and in the popliteal space, the result of the fall. These however were both promptly cured, and only slightly delayed the recovery of the patient.

*Cases of sprains* which come under observation promptly after the accident are usually cured in three or four days by the method described. It was in the treatment of a sprain that the writer first recognized the fact that stasis was an obstacle to be overcome for which nature required assistance, by removal in order to facilitate recovery. It may be said without compromise, that all sprains, where no severe injury has taken place of the ligamentous or bony structures of the joint, are promptly cured by this method without rest or strapping. The same principle applies to the treatment of all joint inflammations.

In cases in which there are indications of toxemia or infection associated with multiple arthritis, the joint, lesions though symptomatic demand treatment similar to that employed in the treatment of the sprained ankle. The main reliance, however, in the treatment of chronic inflammation of the large and small joints, are the static sparks, directed to the soft structures of the joint avoiding direct application to the bony points. These measures produce diffuse deep contraction, and when applied successively to the infiltrated tissue, express or force out the accumulated rubbish from the lymph spaces; and by the removal of pressure permit the restoration of circulation. It may be said that there is in addition a coincident increased blood supply induced by the stimulating effect of the spark discharge as well as removal of the infiltrating products of inflammation.

The application of sparks, likewise, to the tense muscles



which are constantly present with inflammation of a joint, adds another beneficial factor to the treatment of the joint, thereby relieving the increased pressure in the joint on movement. This tension is nature's effort to fix the joint, and thereby produce a cure by ankylosis. Nature's method of curing arthritis is ankylosis, and the surgeon or orthopedist who employs the method of rest in these cases is apt to make the same mistake. In no class of cases is rest more contra-indicated than in arthritis except of tubercular joints, when ankylosis in the late cases is the only probable cure of the condition.

*The management of rheumatoid arthritis, Still's disease, and osteo-arthritis:* The treatment of the joint inflammation is of first importance; but in order to cure the cases, regulation of diet to the requirements of the individual for the correction of the vicious processes uniformly present in the alimentary canal demands coincident attention. They are the element of greatest importance; because they constitute the exciting causes of the condition. The internist however, who attempts to cure these cases by the employment of diet for correction of the intestinal derangements alone, except in the early cases, will meet with failure for the condition of arthritis when once established, will require in addition the local treatment described.

*Infectious arthritis,* including so-called rheumatism, tubercular, gonorrheal and septic arthritis, will be considered in the chapter on the treatment of infectious diseases.

*Pelvic inflammations: Congestions of the non-infected type,* include the congestions associated with dysmenorrhea, subinvolution, ulcers of the cervix, caruncles,

ovarian congestion, prostatitis, vesiculitis, orchitis and epididymitis. These affections are managed with remarkable facility under the same principles of treatment as the non-infected inflammatory conditions.

*Dysmenorrhea and subinvolution* are in a large percentage of cases associated with retroversion which is the natural outcome of the engorgement, the natural supports not being sufficient to keep the heavy uterus in position. This results in most cases in constipation and the train of symptoms and conditions associated with intestinal putrefaction and auto-intoxication. When the retroversion has persisted for a considerable time, the structures of the round ligaments may become so altered that it may never be possible to restore them to their normal tone. It is often possible, however, after removal of the congestion and weight from the body of the uterus for it to remain in proper position without the aid of the normal supports. In all early cases however the normal tone of the supports seems to be promptly restored.

The remarkable facility with which these uterine congestions are relieved, must be witnessed to be appreciated by those who are not familiar with the principle of action and effects of the method employed; because the results from these newer methods are so different from the experience with methods with which most physicians are familiar. This method has been employed by the author since it was discovered by him in the way described in the previous chapter.

Since the discovery, it has been our practice to treat these cases *per rectum* and with uniformly good results. The metal electrode is placed with care so that it will come in contact with the uterine body from the rectal side

PLATE IV. Static Induced Current. One Large Metal Electrode over Abdomen Connected to Pole Having Small Leyden Jar, and Vacuum Tube in Vagina Connected to Outer Coating of Large Leyden Jar.

and is held in position by the patient or with an x-ray tube holder or other device; the patient reclining in a comfortable position upon the side with the back towards the machine or in Sim's position. The wave current is regulated as in other cases; the pain produced by a short spark-gap being the indication of the presence of congestion, and the evidence that the current is affecting a congested uterus; for if normal, it would not cause pain. With the gradual lessening of pain due to the relief of the superficial infiltration the spark-gap is lengthened little by little at each seance. A progressive improvement will be noted as in other cases by the daily increased length of spark-gap which the patient can tolerate from day to day. The treatments are administered daily for twenty minutes until it is possible to start the treatment with the spark-gap of three inches or more; after which treatments are given on alternate days, until within a few days of the menstrual period, when daily treatments should be resumed until menstruation begins; then treatment should be discontinued. If menstruation has been painless, treatments may cease, or otherwise be continued as indicated.

*The prognosis* as demonstrated is uniformly good; the only cases in which favorable results are not obtained are those of *acute flexion, or actual stenosis.* The usual so-called stenosis associated with dysmenorrhea promptly disappears with relief of the congestion of the body of the uterus. Actual stenosis is probably not present in more than one to five per cent. of cases of dysmenorrhea; at least, that is according to the findings of the author.

*When endometritis complicates the condition,* the systematic employment by the method of Dr. Massey, by the

intra-uterine application of the positive pole of the constant current with an amalgamated copper electrode is indicated, applying it with from ten to twenty milliamperes of current for from ten to twenty minutes. This method is employed for the purpose of destroying the unhealthy endometrium. By this method the electrical diffusion of

Fig. 47. Common Metal Rectal Electrode.

the mercury and copper salts into the lining membrane causes it to slough away, to be replaced by a healthy membrane. This treatment should be employed but once and carefully guarded as to dosage, so as not to create too extensive destruction of the endometrium, and should be followed by the systematic rectal employment of the static current as previously described.

Fig. 48. Author's Rectal Electrode.

*Uterine subinvolution* is treated in practically the same manner, but will often be effectually cured in from five to ten seances. In this class of cases no other condition responds so promptly and effectively to this method as the cases of subinvolution. They are, however, more apt to suffer from the derangements of the endometrium, and require intra-uterine treatment than the cases of simple dysmenorrhea.



*The usual electrodes* employed in these cases in which rectal treatment is indicated, is the common straight electrode shown in Fig. 47, or the author's electrode also employed in the treatment of prostatitis, shown in Fig. 48, and an electrode designed by Dr. Arnold Snow which

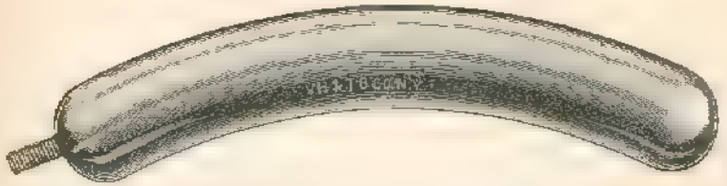

Fig. 49. Curved Electrode Designed by Dr. Arnold Snow.

is curved as shown in Fig. 49. These electrodes have each their special indication and are designed to give as certain contact as possible with the parts treated.

In cases of subinvolution or dysmenorrhea, complicated

Fig. 50. Glass Vaginal Vacuum Electrode.

by cervical ulcerations or an edematous condition of the cervix, it is best to employ with each seance an additional fifteen minutes application with the direct vacuum tube current with a two to four inch spark-gap employing the glass vaginal vacuum electrode shown in Fig. 50. These

electrodes are made in various sizes, and when used as described, the results of treatment are satisfactory.

*Urethral caruncles* are treated in practically the same manner, employing a glass (Fig. 51) or metal urethral electrode of a size which will cause a moderate degree of dilatation employing the direct vacuum tube current or the wave current. Many of these cases will be promptly cured by this method. Others in which there is a growth of hyperplastic tissue, will resist treatment, though in most cases the symptoms are very much relieved.

*In cases of marked vesical irritation* the treatment with a metal electrode placed just above the pubes affords

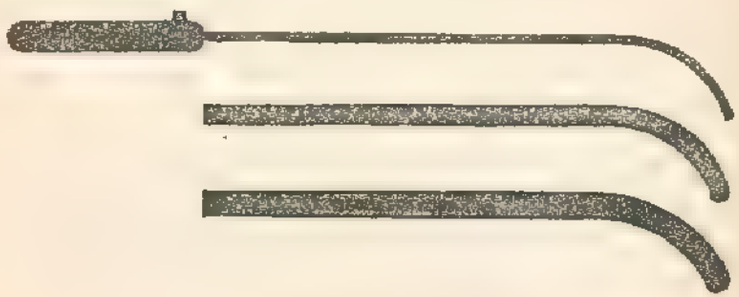

Fig. 51. Glass Urethral Electrodes.

prompt and remarkable relief in a large percentage of cases.

*In ovarian congestions* the symptoms of pain, often designated as ovarian neuralgia, are usually promptly cured with the relief of a subinvolution or dysmenorrhea which is apt to be the cause. In some cases, however, the pain may persist, indicating persistence of congestion. In these cases, the application of the static wave current with a metal electrode directly over the offending organ will



in all cases of simple inflammation effect the relief of the congestion. The operator should be certain to diagnose an infection before employing the wave current lest it he scattered.

*Vaginismus* is usually promptly cured by systematically passing into the vagina vacuum tubes as large as will readily pass employing each subsequent day a larger tube and employing the direct vacuum tube current with a two to four inch spark-gap.

*Prostatitis* as treated by the author's method, has opened a way to the relief and cure of one of the most distressing conditions of the male sex.

*Inflammation of the prostate gland, or prostatic hypertrophy* so-called, arises from numerous causes; and cannot be attributed to anything vicious in the life of the individual, though gonorrhea is undoubtedly the most prolific cause. Bruises upon the perineum, as obtained in horseback riding and bicycle riding, and other mechanical effects, contribute to the early institution of an inflammatory process and as in other inactive sites, the inflammatory process is prone to increase, enlarging the indurated area. In prostatitis the inflammatory process once begun, is disposed to greatly increase. Occasionally a neoplasm or fibroid tissue develops in a gland. This condition however has been found but infrequently. In a previous monograph the writer stated that hyperplasia was probably often present in these cases, and would prevent a reduction of the gland to normal. More recently, however, it seems to have been demonstrated in the author's experience that by persistent treatment, even in old men, the glands may be generally reduced to normal with complete reduction after two or three months of static treat-

ment. These cases do not include the fibroma, of which the author has diagnosed but three in upwards of 150 cases.

*The prognosis in prostatitis,* based upon the author's results by this method is uniformly good except in tubercular or malignant cases. In cases in which a fibroma is present, the relief is marked, though not complete, and in these cases the Roentgen ray is indicated as an adjunct to the static treatment. *Malignant or tubercular prostatitis* will be considered in the next chapter.

*The method employed* is practically as follows: The patient is placed upon the chair, lying upon the side, with the back to the machine as shown in Plate V. The electrodes shown in Figs. 47 or 48, are either held in position by the hand of the patient, or by an x-ray tube holder as shown. Care must be taken that the electrode is well in contact with the gland, and in the median line. If lying laterally, or placed at an angle which will reach the great nerve trunks in the pelvis, on either side, pain will be induced down the course of the corresponding nerve, which will indicate its position away from the median line. In other cases in which the electrode is placed too high in the rectum, the parts will be found very sensitive at the extremity. Care should be taken to place it just far enough into the rectum not to cause pain other than from pressure upon the gland itself. In cases, when the electrode is applied directly to the vesicles, and the current is given rather strong, a disagreeable pain may be induced in the testicles, which may remain for several hours. This is promptly relieved, however, by the application of radiant light and heat.

*The rate at which the spark-gap* is allowed to discharge

PLATE V Showing Method of Holding Rectal Electrode during Administration of the Wave-current.

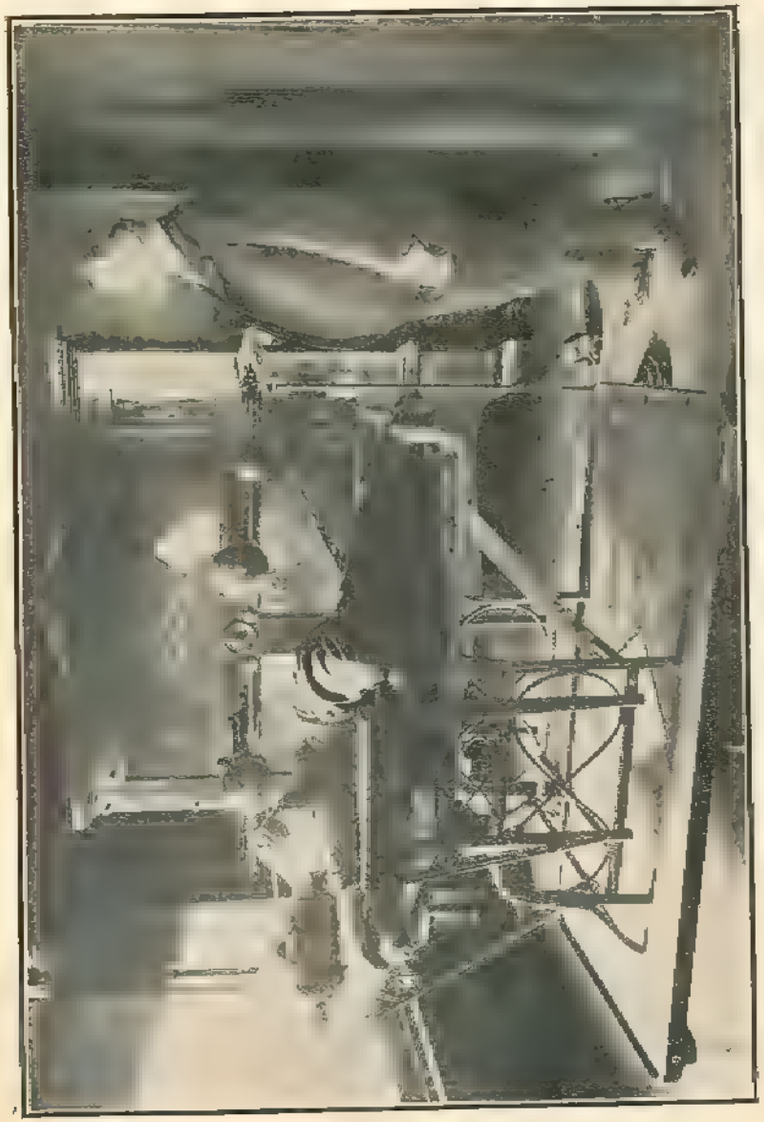

PLATE V Showing Method of Holding Rectal Electrode during Administration of the Wave-current.



is one of the most important points in the technique of this method of treatment. If the spark-gap is discharging at a rate above 300 per minute, a disagreeable pain is apt to be produced due to an intense contraction of the parts. The rate of spark-discharge therefore should not exceed 300 per minute and 120 is to be preferred. This can only be regulated by a means of very uniform speed control; one which will permit of very gradual increase of speed. With each increase of the length of the spark-gap, the speed of the machine must naturally be relatively increased. If the resistance steps, in the rheostat of the direct current motor give too great variation, it is impossible often to regulate the rate of discharge except some other device be provided, which should be unnecessary because with the direct current, in a properly graded rheostat the control should be perfect.

If the power, however, is derived from the alternating current, a mechanical speed control is the only, at present, practical means of regulating the rate of discharge for the properly delicate management of these cases, because it is impossible to regulate the alternating current by any present device to sufficiently delicate changes of speed. The size of the terminal balls of the discharging rods, should not be larger than one and one-fourth inches in diameter; because, otherwise the contractions of the gland will be too violent.

It will be found in some cases that after several days of daily treatment the patient will feel a degree of soreness following the administration, due to over stimulation of the gland by the active gymnastics induced in it by the current. In these cases the treatment should be slightly shortened, or the author has found that the administra-

tion of the current is less stimulating through the medium of a glass vacuum electrode employing the direct vacuum tube current, by the same arrangement as for the wave current with an electrode similar to the one illustrated in Fig. 52. Improvement will be indicated by the increased length of spark-gap that the patient will permit at the outset of the treatment from day to day—the longer spark-gap indicating the progress made in the relief of the condition. When it is possible for the patient to bear a four inch spark-gap at the outset, as long as will ever be required, treatments may be given on alternate days until the gland is reduced to a normal size. The marked relief afforded by the first few treatments in the cases of large

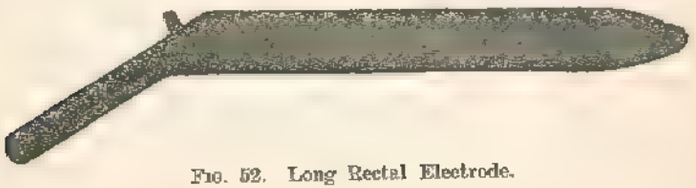

Fig. 52. Long Rectal Electrode.

infiltrated prostates is remarkable. Usually within the first week the frequent micturation is relieved and much of the bladder tone restored. The majority of cases are permanently relieved within a month, though with some patients, in which the condition is of long standing, it is a good policy to continue the treatments for two or three months with a view of reducing the gland to the normal size, which can often be accomplished and is desirable in all cases, thereby forestalling the possibility of relapse.

This effect upon the prostate gland was discovered by the writer when treating an intra-pelvic neuritis in which a large tender prostate was discovered; and it was noted



following the administration that the gland was very much softened and reduced in size. It was more than a year after this effect was noted before it was brought into service; when the following case came under observation beseeching the writer to relieve him from his great suffering both mental and physical.

Mr. G., aged sixty-three, began treatment June 15, 1901, in a state of great depression. He stated that for four years he had been obliged to rise several times each night to void his urine, passage becoming gradually more difficult and more frequent; and during the previous weeks the odor of the urine had become very offensive. He had also been unable to retire at all at night on account of the necessity of continually rising owing to the vesical irritation. Examination of the urine showed the reaction to be alkaline, very offensive, and to contain quantities of mucus as well as numerous pus cells. The treatment employed was the daily administration of the static wave current with a straight metal electrode a cut of which is shown in Fig. 47, for twenty minutes daily. At the first treatment the pain caused by the contraction induced was so severe that a current measured by a one inch spark-gap was all that could be employed. At the close of the treatment however, the spark-gap had been gradually lengthened to about four inches. The patient's great sense of relief after the first treatment was remarked. After four daily administrations the patient was voiding urine with greater freedom and much less frequently, and the character of the urine was less irritating and contained less precipitate. These treatments were continued daily for two weeks, and on alternate days for one week longer, when the patient's condition was so far improved that

he was not obliged to rise at night nor to void urine during the day too frequently, and treatment was discontinued. No other treatment was employed with the static wave current, except the administrations of vesical antiseptics. It is now more than nine years since this patient was treated, and there has been no return whatever of the symptoms; and he has not been obliged to rise nights to void urine, as it had been his habit with increasing annoyance for more than four years preceding the treatment.

The results of treatment in this case aroused the writer to the importance and remarkable possibilities of this method of treatment, which has been followed by the suc-

Fig. 53. Concave Faced Vacuum Electrode.

cessful treatment of upwards of 140 cases since the cure of this first case; and the percentage of relapses has been very slight; and these cases have been promptly cured and remain permanently well.

No work during recent years has given the author greater satisfaction than the treatment of these unfortunate patients; and the cordial support that has been accorded the method and the grateful expressions of appreciation by the members of the medical profession who have become familiar with the method, has amply rewarded the author for the years of labor that he has devoted to the development and advancement of improved therapeutic methods.



*In vesiculitis* care should be taken to carry the electrode high enough and far enough forward to impinge upon the affected vesicles. It is also possible in these cases as in prostatitis to effect a normal condition of the parts.

*In orchitis* apply the proper vacuum electrode, either the usual surface electrode, or one having a concave face as shown in Fig. 53, holding it first over the upper portion of the gland, and gradually as the parts are softened passing it further down, until the tenderness and induration are relieved. It is surprising how effective this method is in relieving this distressing condition. A gland which is so sensitive that it cannot be manipulated prior to treatment is soft and painless on manipulation following a twenty minutes to half hour administration of the current. The spark-gap in this as in all other cases should be regulated to the toleration of the patient.

*In epididymitis* the *modus operandi* is exactly the same and the relief is prompt and certain, employing the same electrodes as in orchitis.

*In varicocele* the indication is to relax the muscular tension of the internal and external ring or the canal where pressure upon the spermatic cord and veins is interfering with the venous return. The author's method of treating these cases is either to hold the convex surface of the rectal electrode shown in Fig. 48, or a piece of metal bent so that the curve will conform with the surface over the canal, held in position with a towel in the patient's hands. Owing to the pubic hairs it may be necessary to thoroughly moisten the parts to avoid the unpleasant stinging of the short sparks. By this means the muscular contractions are relaxed, and the obstructions to return circulation through the vein is removed.

In the early cases, before the vein is materially occluded, the effect is prompt and the cure complete.

In a physician, while under treatment for prostatitis, a varicocele coincidently disappeared as reported by him. This case had been under treatment for prostatitis in the office of one of the best specialists in this city, by massage without relief, and with a loss of ten pounds in weight immediately before he came under observation. After three weeks the condition was cured by the author's method, as previously described, and the variococele had also disappeared, and he had regained the weight lost during the process of massage and was also relieved of a profound condition of neurasthenia.

*Congestion and atony of abdominal organs.* The effects of the static current upon congestion in the abdominal cavity, are the same as in other simple congestions; the induction of successive contraction of the respective viscera, effects the elimination of infiltration and exudation with the restoration of the circulation and function of the parts.

*Malignant disease, tuberculosis of the viscera and other infectious processes* are always to be considered in the treatment by the wave current and static modalities of abdominal congestions; for in any of these affections the application of these modalities are *contra-indicated* and their presence may often be determined by aggravation of the symptoms from the effects produced by one or two treatments when little or no harm may be induced except in pus processes which should always be excluded before the wave current is applied. The age, history and condition of the patient at the time will generally assist in excluding these conditions.



*In parenchymatous and interstitial nephritis* the indications are practically the same. The static wave current should be administered directly over the kidneys, as described in a preceding chapter. The daily application of an electrode six by eight inches over this region and employing a slowly discharging spark-gap of eight or ten inches for twenty minutes will be remarkably effective in relieving the congestion and infiltration of an inflamed kidney, the seat of either type of nephritis.

*Hypertrophic cirrhosis of the liver* can be very rapidly reduced, and the accompanying symptoms relieved, by the application of the wave current with an electrode over the area of congestion. If these patients will discontinue the use of alcohol, and persist in the treatment, the prognosis as to recovery is excellent if instituted early in the case and beneficial in all cases.

*Enlargement of the spleen* of malarial origin is frequently found in patients living in the tropics. Dr. Condict has demonstrated beyond question the efficiency of the wave current in reducing the enlarged spleen in these cases, and restoring the patients to health. In these, as in cirrhosis of the liver, a large plate should be applied over the enlarged spleen, and the spark-gap employed should be long enough to cause marked contraction of the abdominal walls and underlying organs. It is very questionable whether the wave current should be employed in cases of leukemia, partaking so much of the characteristics of malignancy.

*In diabetes mellitus,* the results are remarkable in the cases in which the lesion is of pancreatic origin from the administration of the static wave current with a soft metal electrode over the epigastrium. Cures have been effected

by such employment of the measure. When, however, a high blood pressure is complicating the condition, it would seem to be the cause; because the employment of auto-condensation only has often effected complete disappearance of the glycosuria during the course of treatment.

Dr. de Kraft's method by employing the pulsatory resonator discharges over the abdomen and body of the patient has been reported by him to be remarkably efficient in diabetes mellitus.

*Atonic conditions,* which often result in congestions owing to engorgement and defective metabolism, are relieved by the static wave current, radiant light and heat, and the d'Arsonval current by the direct method either alone or in combination. In these cases the wave current should be administered with a large abdominal electrode and a slowly discharging spark-gap; the rate not to exceed 120 per minute, and to be long enough to produce successive contractions of the abdominal contents.

*Relaxed abdominal walls,* as present in debilitated patients, are restored to normal by this method of treatment.

*Gastric and intestinal atony* with impaired function of the excretory and secretory functions of the alimentary canal, with the consequent constipation, are remarkably benefited by applications of the static wave current in the manner above described.

*In constipated children and young adults* no other treatment is necessary to relieve the condition, though it is customary in these patients to also employ mechanical vibration and radiant light and heat. The same methods should be employed in the treatment of all cases of constipation, arousing as it does to activity the musculature and secretory functions of the alimentary canal.



*In chronic pleurisy with adhesions,* excellent results have been reported from the application of the static wave current over the chest wall. In these cases it is impossible to use so long a spark-gap as is employed over the abdominal cavity, and in all cases it should be regulated so as not to cause too great discomfort to the patient.

*In other congestions* of the simple inflammatory class, wherever found, the static current is indicated as in numerous cases to be mentioned, employing them in accordance with the general principles of dosage.

*Phlebitis,* has received ineffective treatment in the past, as is evidenced by the number of patients who appear with varicose veins. The treatment of a phlebitis by wet dressing with elevation and rest is most impractical; for these methods favor the process, fibrinous adhesions developing an eventual complete occlusion of the vein.

*The indication* here as in all inflammatory conditions is to relieve the infiltration and congestion of the involved vein.

*The treatment* is best effected by the application of the static brush discharge; for in these cases of superficial phlebitis, there is no occasion to employ the wave current or sparks. Furthermore, it is unwise to employ the wave current in these cases lest by too vigorous action an embolus might under some conditions be dislodged, which would not happen by the gentler application of the static brush discharge which is fully as effective. It is the author's practice to employ first radiant light and heat over the affected area, and then to follow with the application of the static brush discharge in cases of acute phlebitis

until the indurated tissues are thoroughly softened. The limb should be bandaged in the intervals between treatment with some flexible material that will sustain and support the part, and prevent swelling of the parts below the obstruction, if the vein is partly occluded.

*In chronic phlebitis* the same treatment should be employed, and the prognosis is relative to the time that the process has been present; for here as in all cases of infiltration, the organized exudation as previously stated will produce occlusion of the vein. It is very often possible to restore the circulation in cases by this method of a year's standing by persistent application with radiant light and heat and the static brush discharge. The author's success in these cases by the method described has been most gratifying.

*Varicose ulcers,* result in most cases from an uncured phlebitis with occlusion of the vein. They are so often intractible by other means; but are promptly cured except in old and long standing cases, when a longer time is required. The ultimate result will be successful by the use of radiant light and the static brush discharge. Many of the milder cases may be cured by radiant light and heat alone but it will require a much longer time than the application of the static brush discharge, because by the static brush discharge the induration surrounding the ulcer is promptly removed; and the circulation re-established to the margin, which, together with the stimulation of the tissues, promotes rapid granulation and healing of the ulcer. This will be the result in the treatment of ulcers not of malignant origin. The author has successfully treated lupus ulcers by the same method but as a rule the x-ray should precede the brush discharge in lupus.



In the treatment of ulcers where much oedema is present, the brush discharge should be applied over the whole infiltrated area until it is softened; after which the ulcer should be dressed, and the limb bandaged from the extremity to the parts above the ulcer. The prognosis in these cases is always good; and the promptness with which they are cured is relative to the chronicity and extent of the lesion.

*Ulcers of the cornea and eyeball* may in most cases be

Fig. 54. Vacuum Eye Electrodes, Single and Double.

cured either by the application of the static brush discharge over the eyelid, or the use of the vacuum electrode (Fig. 54, single and double eye electrode), applied over the eyelid, for ten or fifteen minutes daily, employing a spark-gap that will produce sensible, not painful vibration of the eyeball. These cases, as all inflammatory conditions, should have daily treatment until the condition has disappeared.

*Pterygium* in the early stages may be promptly cured by the same method of treatment as that employed for the treatment of corneal ulcers. It is remarkable how

promptly these dilated vessels contract and disappear in early cases.

*Congestion or obstruction of the tear ducts,* when stenosis has not already occurred by adhesion of the adjacent walls of the canal, are promptly cured by the direct vacuum tube current through the medium of any vacuum electrode which will cover the course of the canal. The promptness with which this condition is relieved is most gratifying compared with the method by dilatation and probing.

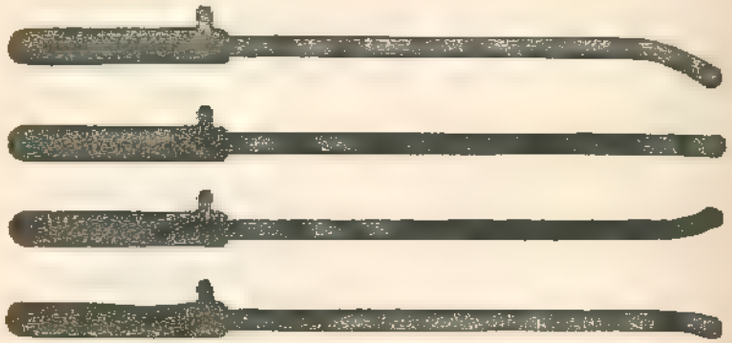

Fig. 55. Variously Curved Vacuum Tubes for Nasal Treatment.

*Glaucoma* in the early stages may be greatly benefited if not arrested, by the application of radiant light and the direct vacuum tube current to the eyeball. The tension is promptly relieved, and the condition if kept under close observation is arrested. This has been accomplished in the case of a lady physician under observation by the author for about two and a half years, the field of vision having been greatly enlarged, and the tension of the eyeball is now absolutely normal. The case was diagnosed by Dr. Valk of New York, and has been under observation of Dr. Broughton also of New York, for more than two years, while under treatment by the author.



*Congestions of the nasal passages* are remarkably relieved and the passages made free by removal of the infiltration by the direct vacuum tube current. The electrodes employed are the flat nasal and the curved nasal shown in Figs. 55 and 56. The administrations are made daily for from ten to fifteen minutes, the rule in all cases

Fig. 56. Eustachian Electrode.

when this current is employed, until marked improvement is made, and then on alternate days. The effect of this plan of treatment is usually to leave the nasal passages open, at least on one side if there is a deviated septum. The method should also be employed, in the author's judgment, after all operative procedures in the nasal cavities, as after the removal of the turbinates.

Fig. 57. Electrode for Treating Turbinates and Meatus of Eustachian Tube.

*In postnasal ulcers* the direct vacuum tube current with electrodes variously shaped for adaptation to surfaces requiring treatment, are remarkably efficacious in removing the induration and healing ulcerations. The electrodes shown in Figs. 57 and 58, are often of aid in reaching remote places in the nasal cavity.

*Hay fever,* has been successfully treated by Dr. Tice of Roanoke, Va., by an electrode designed by himself, Fig. 59. In the treatment of these cases he first applies a nasal spray of an oily consistency and then applies the electrode far back in the nares for ten or fifteen minutes daily. The results reported are very encouraging.


Fig. 58. Dr. Tice's Nasal Electrode.

*Chilblains following frost bite* are very promptly relieved by the thorough application of the static brush discharge to the involved parts of the feet until the infiltration and consequent soreness is entirely removed. The author has never used a method which has given such satisfaction

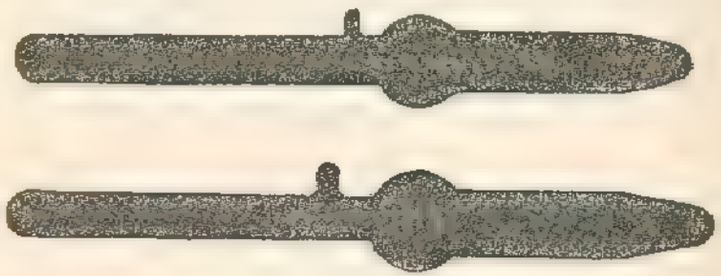

Fig. 59. Dr. Arnold Snow's Hemorrhoidal Vacuum Electrodes. Three Sizes.

as the static brush discharge in these cases.

*In simple ulcers of the rectum,* the application of vacuum tubes is always efficacious if the application is made directly to the tissues surrounding the ulcerated surfaces. With the induration removed, these ulcers heal promptly.

*Fissure in ano* is always successfully treated by the



employment of a vacuum electrode which will slightly distend the anus as the hemorrhoidal electrode shown in Fig. 60, hemorrhoidal electrodes designed by Dr. Arnold Snow, employing the direct vacuum tube current for fifteen minutes daily. The bowels should be kept loose for five or six days to permit healing of the edges. The principle here as in other processes is, that the induration is removed from the edges of the fissure, when the surfaces rapidly heal. No better method can be devised for the treatment of these distressing cases. If an electrode is used large enough after the first application to pass in and distend the anus, it is also capable of overcoming the anal spasm thereby greatly facilitating the healing process.

*In hemorrhoids* the treatment by the vacuum or metal electrode is effective in all early cases associated with the removal of the cause. In these cases the induration is not of an organic character, and the infiltration is promptly relieved and tone restored to the hemorrhoidal veins. The electrode shown in Fig. 59, was designed by Dr. Arnold Snow for the treatment of these cases. The shoulder of the electrode should be pressed firmly against the external hemorrhoids if present. These electrodes are made in three sizes, and should be used with a view to distending the anus after the first treatment, in order to overcome the muscular spasm of the sphincter ani muscle.

*Following operations for hemorrhoids* the employment after the first five days of the same electrode as is used in the treatment of hemorrhoids, will remove the infiltration from the margins of the operation wound, promptly relieve the suffering and discomfort of the patient with the first treatment, facilitate the healing, and prevent subsequent formation of scar tissue and consequent narrowing of the

rectal canal. No more sane or sensible method can be employed than this in connection with the surgery of the rectum. It is cordially recommended to the surgeon and his patient.

*Glass vacuum electrodes* are generally used in the mucous cavities because they combine with the action of the current in addition to inducing contraction; a local antiseptic effect which is important in the mucous cavities.

*Contusions* with or without trauma should be always treated on the same principle as sprains and other non-infected inflammatory conditions. The brush discharge on or about a trauma or the wave current brush discharge or direct vacuum tube current over a bruise will remove every evidence of soreness in two or three applications. It is of the utmost importance to apply these measures over bruises particularly of the female breast, to which are attributed so often the cancer which appears in later years.

*Ecchymoses* disappear with remarkable rapidity under the applications of the static brush discharge. The cellular gymnastics induced in the tissues increasing absorption and elimination of the cells by the lymphatic channels.

*Following fractures or dislocations,* the employment of the static brush discharge over the swollen or painful structures relieves all of the pain and tenderness. When a fracture is put up in thin veneer splints of wood, it is possible to make the application through the dressing relieving the swelling and promoting a more rapid repair of the process. Particularly valuable is this in treating fractures in the vicinity of the joints in which ankylosis is apt to occur.



The following case illustrates the efficiency of these modalities in the treatment of severe injuries.

The author recalls a case of severe injury of the foot in which that member was swollen to above twice the natural size, and contused at two points, with ecchymosis extending from the toes back to within an inch or two of the heel, a heavy weight having fallen upon it. With treatment, this man, a laborer, was able to resume work within a week from the time of the injury and to walk within two days with but slight discomfort. The first application of the brush discharge to this foot, following the wave current, required forty minutes to soften the tissues, and at least half that time at each subsequent daily administration; the relief that was afforded however, was ample reward for the time expended. Such results can be obtained, we believe, in no other manner, and probably the static brush discharge is better adapted for the treatment of superficial contusions than any other modality. In lieu, however, of the static machine, the resonator sparks from a coil are of great value.

## CHAPTER VII.

### TREATMENT OF INFLAMMATION CAUSED BY INFECTION

Inflammation which is caused by infection can only be treated successfully by the termination of the infectious process, which is, therefore, the indication of first importance to be observed.

Left to natural processes, infection may be limited by the walling in of the germs until they perish finally by attenuation and overgrowth in the limited space in which they exist. The pressure due to the limited cavity in which the germs develop, causes pain during a suppurative process, and terminates the process finally with evacuation of the germs in the direction of least resistance. This is the usual course of a pyogenic infection.

In other cases in which the inflammatory process is less active, as in tubercular infections, the inflammation may extend gradually involving the surrounding tissues, thereby broadening and enlarging the scope of infection. While the latter action is insidious, the destructive action by the growth and extension of the germs in the lower grades of inflammation, lead to more extensive disintegration of the structures of the region involved.

The germs most commonly the sources of localized inflammation are the streptococci, staphylococci, pneumococci, tubercle bacilli, gonococci, anthrax, the germs of typhoid fever and tetanus, and in the early stage of infection the spirilum of syphilis. Most other germs act upon the organism with the production of a general infection from the outset, with





some specific or localized manifestations, as do the exanthemata.

The conditions which favor the institution of an infectious process upon the organism, particularly the tubercular, streptococcic, staphylococcic and pneumococcic infections, is a lowered resistance or phagocytosis, which favors the implantation of the germs in a colony where they will not be promptly destroyed by the natural scavengers. Likewise, the restoration of the individual once infected is more speedy and prompt when the index of resistance is relatively high. Wright in his researches has shown that under certain physical conditions, phagocytic activity and capacity to take up germs is greater while in other individuals they will take up many less when exposed to similar infection.

Influences which undermine the general health and nutrition of the individual lower the index of phagocytosis, under which conditions an invasion will be more likely to take place and the process will be more active and less limited in extent.

It is under conditions of lowered resistance that individuals are much more susceptible to streptococcic, staphylococcic and tubercular infection. In these cases of lowered resistance response to physical treatment is also relatively slow.

*The indication for the treatment* of every case of infection, therefore, points first to the increase of the individual's resistance, or capacity to wall off or bar the inroads of infection, which demand the improvement of general and local metabolism by systematic regulation of nutrition which will depend upon the observance of such a hygienic, dietary and sanitary regime as will tend to restore and preserve the health of the individual. For example in tuberculosis the cause which led to it must be first discovered and corrected, as well as keeping the patient out of doors in the fresh air. The regu-

lation of diet and exercise and the correction of metabolism as accomplished by efficient means including radiant light and the high potential currents are all indicated in persons whose resistance is lowered. When a fairly active metabolism cannot be maintained by exercise, such measures as radiant light and heat, the electrical currents, massage, or other means which arouse the functions must be employed to improve both the general and local activities.

The means which are employed in the treatment of local infection, are (1) those which act directly upon the germs to destroy them, which is often possible when they are accessible as when they are at the surface, by the employment of radiant light and the high frequency currents; (2) agents which while inhibiting or lessening the activity of the germs, co-incidently increase by the induction of hyperemia the activity and presence of phagocytes in the region of infection, and may coincidently arrest the activity of the germs: and (3) the use of means which arrest the proliferation of the germ processes as do radium and the Roentgen ray.

The scope of this work is confined to the employment of the high potential currents, but it is important that reference be made from time to time to other measures which assist in arresting infectious conditions by the local destruction of germs.

The high potential currents, particularly those of high frequency, are remarkably efficient in inducing hyperemia in the tissues. Probably no condition plays a greater rôle both from the point of view of increasing local tissue resistance and local metabolism, than hyperemia with the presence coincidently of a greater number of phagocytes in the tissues; and for the induction of hyperemia no agent is so effective as these currents.



The employment of the means referred to, for the treatment of local infection were considered at length in a previous chapter.

*The application of the vacuum tubes* excited with the proper energy to the surface, when the lesion is superficial, induces sufficient hyperemia to effectively abort or arrest infection by the hyperemia induced, and when very superficial by the direct action, actinic and antiseptic, upon the germs at the surface and a little distance within the tissues.

*The vacuum tube discharges* are particularly efficient in the treatment of infection within the mucous cavities, and to small boils and carbuncles superficially located. When the direct d'Arsonval current is passed directly through the tissues and the vacuum electrode is applied from one terminal over the infected region, hyperemia is induced to a greater depth, and with greater certainty than when applied from an Oudin or other one pole current.

*The static direct vacuum tube current,* employing a vacuum tube connected directly from a static machine and with the same arrangement (Fig. 1), as the static wave current, may also be employed effectively in the treatment of early infection; i. e. during the first stage of an infection; when the irritation indicates the beginning of an infectious process, but before a pus cavity is established. By this means it is possible to abort a felon or furuncle, or suppurative tonsilitis in its first stage, and arrest the process. The application is made with the employment of as long a spark-gap as can be borne by the patient without producing too great suffering, and is continued until the tissues are thoroughly softened which will require from ten to twenty minutes, when the few germs are let loose in the tissues, to be destroyed by the phagocytes. The application may have to be repeated on

one or two days following the first treatment. There is no danger when employing this method in the first stage of infection; but after approximately thirty-six hours, great care must be exercised, lest the infectious process may have developed so many germs that they will be scattered and the infection extended.

*The direct d'Arsonval method of treating infection* presupposes the induction of an intense hyperemia throughout and surrounding the region infected. The idea of considering the use of any method without the recognition of the factors which enter into the result, is too often the disposition of pioneers. That habit, however, always leads to confusion, and the adoption of empirical methods, which for the enlightenment of the student, is unsatisfactory. The principles of action of every modality upon the tissues should be fully recognized by all who expect to use it intelligently.

*Hyperemia in the tissues as previously shown,* effects three important results; (1) the increased flux of blood through the tissues increases metabolism, both anabolic and catabolic; (2) it supplies to the tissues the needed nutrition for repair and (3) it carries into the tissue with the increased blood flux, a proportional increase of the phagocytes which last exercises the chief influence of hyperemia upon infection. Another element to be recognized in connection with this increased flux through the tissues, is a tendency when the capillaries and arterioles dilate, to force the circulation through the tissues; thereby when employed early resolving or preventing the establishment of local stasis. When once established, however, with the presence of marked swelling and induration it is impossible to resolve stasis by these measures. When a pus cavity is once established, hyperemia plays no important rôle until the pus is evacuated, after which the induction of hyperemia by the employment of radiant light and heat and high frequency currents, favors rapid restitution of the parts. This principle applies more particularly to the streptococcic and staphylococcic infections; whereas in the low grade tubercular infections, or other infections in which induration is not established to the same extent, the tissue being much more relaxed and flaccid permit the circulation of blood throughout under the stimulus of any agent that produces heat and with it active hyperemia in the tissues. The vaso-motor reflexes provide that wherever the tissues are heated or cooled, there will be an increased flow to the part with dilatation of the arterioles in the region so infected.



The bipolar direct d'Arsonval method is employed for *thermic* effects with a current of the requisite amperage passed directly through the part involved. The tissues are thus heated to an extent relative to the amperage of the current employed and the size of the two opposite electrodes. By this method it is possible to affect deep seated infection, as in the pelvis or liver, and is always indicated in such processes. It must be borne in mind, however, that when an infection is immediately beneath the surface, it is better to employ the vacuum tube over the site of infection as previously described, because the thermic effect of the direct d'Arsonval current is, as a rule, more marked at a point about midway between the two electrodes; but when the vacuum tube is employed at the surface, the hyperemia will be more marked there also.

*The treatment of otitis media, mastoiditis and suppurative processes in the frontal sinuses* is probably most effective when treated by prolonged applications of radiant light and heat from an intense radiating source as from the focussed light of a fifty candle power incandescent lamp, held close

enough to require moving about to prevent discomfort to the patient. In these cases the application of the high frequency current with vacuum tubes are probably not so effective as light, but may be always considered as congeners in the treatment of these cases. Radiant energy undoubtedly penetrates more deeply into bony structures than the high frequency currents, and is more effective as a means of inducing hyperemia in these cases.

*Pelvic cellulitis, salpingitis, and gonorrheal infection,* are best treated by the high frequency current employing the direct d'Arsonval method with one electrode placed immediately above the pubis, and the current passed directly through the pelvic structures for twelve to fifteen minutes, when metal is used in the rectum instead of glass the current may be applied for a longer time because it does not irritate the mucous membrane as the vacuum tube discharges do. The current when employing the vacuum tubes should be used with a volume that can be tolerated at the rectal side. The dosage in the employment of the direct d'Arsonval current in most cases, must be regulated to the thermic toleration of the patient, which will as a rule not be so great when a vacuum electrode is used as previously explained.

*In abscess of the liver, or appendicitis, chronic or acute,* the same principle of application is employed as in the treatment of pelvic infection, though it is often better in these cases to employ two metal electrodes at opposite sites in such a manner that will be certain to convey current through and around the infected parts.

*In adenitis, either tubercular or streptococcic,* the high frequency current by the bipolar direct d'Arsonval method should be employed following a series of applications of the Roentgen ray—applying the ray until a dermatitis has been reached,



and then persisting with the hyperemia employing congeners —the high frequency current and radiant light and heat— to the parts involved. By this method it is possible to effectually arrest or abort these cases with few exceptions; the exceptions as a rule being due to want of thoroughness in technique.

*In pulmonary tuberculosis,* the indications, as previously suggested, are to improve in every way possible the metabolism and nutrition of the patient, and when there is an associated high arterial tension, to employ the auto-condensation method both for the effects upon blood pressure and general metabolism. Following a series of irradiations with the x-ray over the lungs, the employment of the direct d'Arsonval current, applying on alternate days a large metal electrode over the chest in front, and a vacuum electrode over the back, moving it about over the surface regularly, changing the sites of application on alternate days, so that the metal plate and vacuum tube are employed alternately front and back on the chest wall. The hyperemia, deep and superficial, induced by this method following the x-ray favors the destruction of the local infection; and with these applications the patient's nutrition and appetite steadily improve, with a corresponding improvement in general phagocytosis, and the process is arrested.

There is no doubt that in these cases the application of radiant light and heat and the high frequency currents have a decided action upon the blood, circulating where hyperemia of the skin is present—increasing the percentage of hemoglobin, and by the stimulated activity of lymphatics and sweat glands ridding the blood of deleterious toxins.

*In cold abscesses* there is probably little to be expected from these applications, though it is possible that in some instances

with the increase of general resistance by the employment of active measures, which improve general metabolism and nutrition, that they may to a degree effect the absorption of the accumulated pus.

*In tubercular and other infectious types of arthritis,* in which the germs are present in the joint, the most effective method of treatment is the application of the bipolar direct d'Arsonval current either by the application of two metal electrodes or one metal and one surface vacuum electrode passing the current directly through the affected joint, with a current capable of producing a temperature sufficient to cause a sense of warmth through the tissues. Here as in other infectious diseases the induction of hyperemia and phagocytosis in the tissues is remarkably effective in the early cases in bringing about the restoration of the joint.

These administrations however, should be preceded by a series of x-ray irradiations; when radiant light and heat may also be employed in conjunction with the high frequency current. The x-ray should be employed until there have been enough regulated short exposures given on alternate days to produce a commencing dermatitis, when the agents which induce hyperemia should be employed daily, and with energy until the joint is well and every sign of infection is removed.

*In tubercular adenitis* practically the same routine is employed as in other tubercular inflammations, employing the x-ray on alternate days with ten minute exposures with the usual intensity of x-rays until the glands disappear, or a dermatitis occurs; when, if the bipolar d'Arsonval current is employed with a surface electrode of metal back of the gland, and a vacuum electrode over the gland, for the induction of active hyperemia in many cases a cure is promptly effected. In other cases it may be necessary to resume the x-ray and



follow out the same routine with the bipolar high frequency current, after the dermatitis occurs. The improvement in general health of these patients and gain in weight is remarkable. No measure is more effective in any class of conditions than the combined use of the x-ray and high frequency current in tubercular adenitis.

While the x-ray is effective when used singly in these cases, if the high frequency current is employed, and is successful after the first irradiation, the functions of the gland are much less impaired than if the x-ray is persisted in alone until the case is cured.

*Local tubercular affections* wherever present, should be treated on the same general principles as in the treatment of tubercular arthritis and tubercular adenitis.

*In gonorrheal arthritis,* in which the germs are propagating at some foci of active infection, of which the joint is but a toxic manifestation, the indication is always to relieve the local infection. In chronic cases this is as a rule in the vesicles prostate or veru montanum. If so the application of the bipolar direct d'Arsonval current with a glass vacuum electrode (fig.42) placed against these structures, and a metal electrode above the pubis for ten or fifteen minutes, followed by fifteen to twenty minutes of the static wave current against the prostate and vesicles in the rectum is uniformly effective.

The high frequency current should be applied in a manner which will produce as much heat as possible without causing an uncomfortable sense of heat in the tissues. Under these conditions there will be a sense of general warmth and in most cases the patient will perspire.

In some cases it may be necessary to make the application of the high frequency currents to the veru montanum

through the urethra which may likewise be the seat of infection, and sources of the toxemia. In most cases however the condition will be relieved by the rectal application.

Cases that have been crippled for weeks and months are promptly relieved and cured by the combined method, which consists in applying the vacuum electrode by the bipolar method with the direct d'Arsonval current placing a small metal electrode over the pubis and a glass vacuum electrode in the rectum, followed by a twenty-minute application of the static wave current with the metal rectal electrode placed well up in contact with the prostate and vesicles. The direct vacuum tube current is also efficacious when employed in conjunction with the static wave current in these cases.

Reports have also been made of numerous cases in which the wave current alone has cured these cases. On general principles however, the hyperemic and antiseptic effects of the vacuum tube currents add another promising element in the treatment of these cases.

*In acute epididymitis* of gonorrheal origin the following method is remarkably effective. Apply the vacuum tube directly over the site of the lesion and have the patient hold it in contact employing the direct vacuum tube current with an ordinary surface electrode or what is better one having a concave face (fig. 53). These cases are usually cured in this manner in two or three applications: the relief afforded by the first application is certainly remarkable. The electrode should be applied to the tender surfaces over the induration, moving it about until the part is softened and not very sensitive to manipulation at the first administration. The chair in which the patient is seated should be placed at such an angle with the static machine, that the connecting cord or wire will not come in contact with the patient's body or



arms during the administration. With one hand on the vacuum tube holder the electrode should be held in position with the other hand with a towel between the electrode and the hand. The spark gap should be lengthened until it causes as much pain as can be tolerated by the patient without causing too great discomfort and the administration should be continued until little or no pain is caused at the site of the lesion when a long spark-gap is discharging. There is no little manœuvre in medicine that will more favorably impress the genito-urinary surgeon than the treatment of an epididymitis by this method.

*Acute and chronic appendicitis* may often be treated and relieved by the employment of radiant light and heat and the direct d'Arsonval current, employing the same principles and methods of treatment suggested in the preceding paragraphs. It is well in the *chronic cases* to precede the treatment for the induction of hyperemia by the x-ray following very much the same routine as in the treatment of tubercular arthritis. The results are quite remarkable and in the majority of cases of chronic appendicitis it is possible to restore the parts to normal or a fairly healthy condition. In a great many cases of *acute appendicitis,* five or six daily applications of radiant light and heat of twenty to thirty minutes each, will effectively arrest the process as will be evidenced by the fall of temperature, relief of muscular tension, spasm, and pain. These results have been obtained by the writer so frequently that he feels justified in recommending their employment.

*In salpingitis, pelvic cellulitis, and pyo-salpinx,* the effects of the direct d'Arsonval current and radiant light and heat are often most remarkable and in the early stages will arrest the active processes, and in chronic cases when employed in conjunction with the Roentgen ray as in other infectious

conditions, will often produce results which will eliminate the necessity of operative procedures.

*In infectious conditions often present in the mesentery and colon,* the effects of the direct d'Arsonval current and radiant light and heat are likewise remarkable, altering the infectious process and co-incidently quickening the processes of metabolism and absorption. There are probably no means which give greater assistance to the internist than the treatment of *chest, abdominal* and *pelvic* conditions by the joint administration of radiant light and heat and the high frequency currents.

## CHAPTER VIII

### THE METHOD OF EFFLEUVATION OTHERWISE DESIGNATED FULGURATION

The application of a high frequency discharge from a metal point with a current of sufficient energy to destroy living tissue, was first described and instituted by Dr. J. A. Riviere of Paris, France. He employed the method for the destruction of epitheliomata, warts, moles and condolomata. His student, Kaeting-Hart, employing the same method in connection with the operative treatment of cancer of the breast, with a view to prevent secondary recurrence by following the knife with the application of the same method designated the process as "fulguration," giving the original investigator no credit for the originality of the method. His associations as a surgeon led to the adoption of the latter name which is the designation of the effect and not of the method; the method being a hot effleuve discharge and the effect one which simulates burning.

The process of effleuvation may be applied either for a cauterant effect or as a desiccating agent as described by Clark;* the discharges in one case destroying the tissue by actual chemical decomposition of heat, and the other process by applying the current with sufficient strength to produce a drying out of the tissue with the induction of coagulation-necro-

*Oscillatory Desiccation in the Treatment of Accessible Malignant Growths and Minor Surgical Conditions. A New Process. Dr. William L. Clark, Philadelphia, Pa., Journal of Advanced Therapeutics, April, 1911.

sis. When thermic application is made in the tissues, above 73° C. coagulation-necrosis is induced.

Another method which to a degree stimulates effleuvation in its effects, though not in the methods of application, is the passage of the direct d'Arsonval current through the tissues employing a large indifferent electrode of metal from one terminal to the surface of the body and a very small operating electrode from the other d'Arsonval terminal. By this method employing operating metal electrodes of different sizes varying from that of a needle to an electrode having a surface of

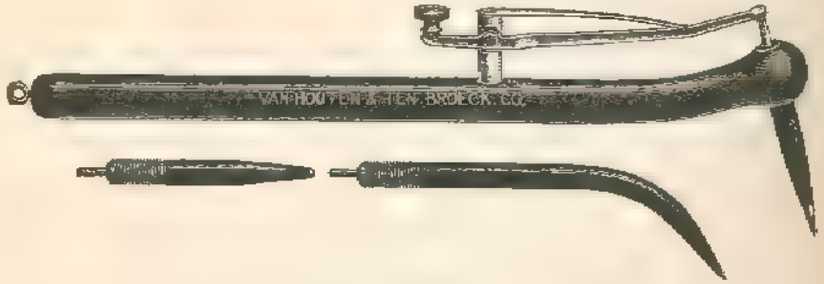

Fig. 61. Dr. Cannon's Effleuvation Electrode.

one or more millimeters in diameter, it is possible to locally destroy tissue by the induction of coagulation-necrosis.

In the application of these different methods, the effect is practically the same, the tissues being destroyed; but where the growth is very superficial, the method by effleuvation employing electrodes designed to get the desired degree and extent of destruction by the application of the long curved electrode to the tonsils, renders the process a very easy one to employ. Cuts are shown here of different designs of instruments for making applications by this method.

*The Technique* will depend somewhat upon the apparatus to be employed. In connection with the small portable high



frequency apparatus, or the resonator of a static machine or the Ruhmkorff coil the operator should test the strength of the current upon his hand before beginning the application. The possible spark length should not exceed one-sixteenth to one-eighth of an inch, and the current strength or amperage should be regulated to the demands or intent of the operator necessary to meet the indications. For small superficial

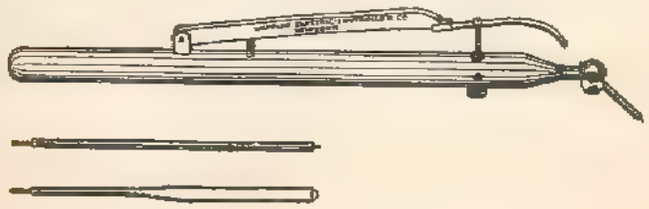

Fig. 62. Wappler Fulgurating Electrode.

growths, it is not necessary that the current should be of great energy.

The area to be treated should be well cocainized either by the introduction of the cocaine by the hypodermic, or the ionic method, or by direct application to the mucous surfaces of a 10% solution.

The dosage or extent of the application to a particular condition is largely a matter of personal experience. Every operator should acquire his technique by beginning with the treatment of superficial skin conditions.

# GLOSSARY

*Alternating Current.* One which flows alternately in opposite directions usually so quickly that it is assumed to have *no polarity*. The speed of alternations is expressed in frequencies.

*Am-meter* (or Ampere-meter). An instrument, calibrated in amperes or arbitrary divisions, to indicate the strength, density or *quantity* of current passing in a circuit.

*Amperage.* Strength of the electrical current expressed in amperes.

*Ampere.* The unit of density, or quantity, or strength of an electrical current.

*Anaphoresis.* The transmission by ionization of electro-positive bodies into the tissues, applied from the positive pole.

*Anion.* A term applied by Faraday to that element of an electrolyte which in electrochemical decompositions appears at the positive pole, or anode, as oxygen or chlorine.

*Auto-condensation.* A method of administering the d'Arsonval current to the patient upon a couch having an insulated cushion underneath the entire length of which is a metal condenser plate, connected by a metallic conductor to one end of the d'Arsonval coil, the patient being connected to the other end.

*Auto-conduction.* A method of administering the d'Arsonval current with the patient standing or sitting within a large solenoid which is connected at its ends to the two terminals of a d'Arsonval solenoid; the magnetic lines of force passing through the body of the patient, who becomes a conductor of the electric currents induced thereby.

*Brush-discharge.* In electrotherapeutics, the discharge, disrupto-convective in character, peculiar to the passage of an electrical current through resisting substance as a glycerine tube or damp wooden electrode, which produces a discharge which causes a sensation as of hot sand when it comes against the skin of the patient. This term is also applied in electro-physics to similar discharges in air or gases, from any high potential source.

*Capacity.* The property by which a given body will take and hold an electrical charge.

*Cataphoresis.* The transmission by ionization of electro-negative bodies into the tissues.

*Cathode.* The negative or antipode of the anode element in an electric couple.

*Cathode Stream.* The electrified particles passing in the attenuated medium of a vacuum tube from the cathode to the anti-cathode; and marking the direction of the electrical current flow. The manifestation of the cathode stream has demonstrated the error of the long-recognized view, that the electrical current passes from positive to negative, it being now understood that the current passes with the cathode stream in the opposite direction.

*Cation.* The name given by Faraday to the element or elements of an electrolyte which in electrochemical decompositions appear at the negative pole or cathode, as hydrogen.

*Circuit-breaker.* An electro-magnetic device actuated by excess of current; in some cases used instead of a fuse; a switch.

*Condenser.* Any apparatus by which electricity can be accumulated, usually consisting of two conducting surfaces, separated by a non-conductor; as the Leyden jar, or metal plates separated by glass or mica insulation.

*Conductive Discharges.* Discharges of an electrical current through a metallic conductor to the patient.

*Conductivity.* The capacity of a body to conduct a current. The best conductor is that which offers the least resistance.

*Convective Discharges.* Discharges from a high potential source which pass in the form of visible or invisible streams of electrical energy through the air to the patient; as the static spray and breeze.

*d'Arsonval Direct.* A method by which the current between the opposite terminals of the d'Arsonval solenoid are passed directly through the patient between two electrodes.

*d'Arsonvalization.* The administration of electricity by the method of Prof. d'Arsonval, employing the d'Arsonval current with either the auto-conduction, auto-condensation or the direct bi-polar method.

*Detonating Chamber.* A muffler surrounding the discharging balls of a static machine or resonator for deadening the sound of a spark discharge.

*Dielectric.* An insulating substance through or across which electric force is acting by induction without conduction—as the walls of a Leyden jar, the insulating cushion of an auto-condensation couch, or an air space.

*Direct Current.* A current flowing in one direction. It may be constant pulsatory.

*Direct Vacuum Tube Current.* A current administered from one pole of a static machine, the other pole of which is grounded, and regulated by the discharging spark-gap, with which vacuum electrodes are used instead of the metal electrodes employed with the static wave current which is administered in a similar manner.

*Disruptive Discharges.* Electrical discharges which escape suddenly by breaking down the dielectric air-gap; static sparks.



*Disrupto-convective Discharges.* The static brush-discharge which simulates both the convective effleuve and the disruptive or spark-discharge.

*Dry Heat.* In contradistinction to moist heat, heated dry air as used in an apparatus designed for the induction of hyperemia, which on account of dryness rapidly absorbs the moisture of perspiration from the skin in the apparatus during the administration. A degree of ventilation in the apparatus is necessary lest the air become moist from evaporation of the patient's perspiration.

*Effleuve, also effluve.* A convective discharge of a high potential current through a dielectric.

*Effluvation.* A method of applying an electrical discharge in the tissues by an effleuve for the purpose of destroying redundant or diseased tissue.

*Electricity.* "A material agency which, when in motion, exhibits magnetic, chemical and thermal effects, and when at rest or in motion exerts a force upon other electricity. Recent investigations indicate that it is discrete or granular in nature and there may be two kinds, namely positive and negative."—*Sheldon.*

*Electrify.* To cause electricity to pass through. To charge with electricity.

*Electrize.* To make electric. To electrify.

*Electro-cautery.* An apparatus for cauterizing tissue consisting of a platinum wire in a holder which may be heated to a red or white heat by a current of electricity when connected in the circuit.

*Electrode.* A medium used between an electric conductor and the object to which the current is to be applied. In electro-therapy an electrode is an instrument with a point or a surface from which to discharge current to the body of a patient.

*Electrology.* The department of electro-therapeutic science which treats of the phenomena and properties of electricity.

*Electrolysis.* The electrical decomposition of a chemical compound; as of the electrolyte into its constituent parts by an electrical current.

*Electrolyte.* A compound which is decomposible or is subjected to decomposition by an electrical current.

*Electro-motive Force* (E. M. F.) That effect of difference of potential which, upon closing a circuit, determines the flow of electricity from one place to another, giving rise to an electrical current. The strength of an electrical current is directly proportional to the electro-motive force, and inversely proportional to the resistance (Ohm's law). Electro-motive force is measured in volts.

*Electron.* A particle of electricity of infinitesimal smallness, more than eight hundred times smaller than the atom of hydrogen, from which have been resolved the negative electrons. It has been maintained that there are no positive electrons; but the tendency of modern theory is to disprove this notion.

*Electro-negative.* Repelled by bodies negatively electrified, and attracted by bodies positively electrified.

*Electrophorous.* An instrument for obtaining static electricity by means of induction.

*Electropoion.* A mixture of sulphuric acid, bichromate of potash and water, used as the liquid for batteries in which zinc and carbon are the elements.

*Electro-positive.* Attracted by bodies negatively electrified, and repelled by bodies positively electrified.

*Electro-static.* Pertaining to static electricity.

*Electro-therapeutics.* Treatment of disease by means of electricity.

*Electro-therapeutist.* A physician who studies or practices electro-therapeutics.

*Electrotonic.* Of or pertaining to electrical potential.

*Electrotonus.* Of or pertaining to electrical potential.

*Frequency.* The rate of oscillation or alternation in an alternating current circuit, in contradistinction to periodicity in the interruptions or regular variations of current in a direct current circuit.

*Fulguration.* Destruction by flashing or sparking or similar application of electrical heat. (See Effluvation.)

*Fuse.* A device comprising a fusible metal the conducting capacity of which is predetermined and which fuses through heat generated by the passage through it of excess of current. It breaks the circuit and so saves an apparatus from overload. Convenient forms are mounted in plugs; or between hard metal ends confined under screw-heads.

*Galvanic Current.* That produced by a chemical battery.

*High Frequency.* The rate of alternation or oscillation in an alternating current circuit, exceeding the rate at which muscular contraction ceases; approximately 10,000 per second.

*Hypertension.* Excessive tension. In medical usage, an arterial tension above normal.

*Impedance.* The opposition to current flow which is the sum of ohmic resistance plus apparently additional resistance due to induction.

*Insulation.* The state in which the communication of electricity to other bodies is prevented by the interposition of a non-conductor; also, the material or substance which insulates. Insulation is measured in meg ohms.

*Inductance.* The apparent resistance due to induction in a circuit, specifically, to coefficient of self induction.

*Insulator.* That which insulates; specifically, a substance or body that interrupts the communication of electricity or heat to surrounding objects; a non-conductor; anything through which an electrical current will not pass.



*Interrupter.* A mechanical or electrolytic device for making and breaking (closing and opening alternately) the low voltage direct current circuit of the primary winding of a Rhumkorff coil or other electrical apparatus.

*Inverse Current.* An erroneous expression for the induction, developed in an electric circuit, in opposition to the flow of the current established at the instant of closing the circuit.

*Ion.* One of the elements of an electrolyte, or compound body undergoing electrolyzation.

*Ionic Medication.* Ionization or transmission of metallic or organic ions into the tissues by an electric current.

*Magnetic or Electrical Field.* The zone or space within which the potency of these influences is effective.

*Farad.* The unit of static charge capacity.

*Milli-am-meter, or Milliampere-meter.* An instrument calibrated in milliamperes to indicate the value of small currents drawn from a battery or coil, or transformer, usually for electro-therapeutic and laboratory work. N. B.—A milli-ampere is 1/1000th part of an ampere, and in the scaling of meters for readings on direct current circuits the calibration is on this basis. But in the case of milliampere-meters for indicating high frequency currents from resonators to subject, it must be understood that the readings are really the product of relative current strength and frequency. The indications are the effect of temperature variations on a wire, the temperatures being affected by the amount of energy represented by the current. In the standard Gaiffe meter the scalings of electro-therapeutic instruments are often arbitrary, and therefore, while they are relative and useful, they are not standard.

*Milli-ampere.* 1/1000th part of one ampere. (See Milliampere-Meter.)

*Modality.* In therapeutics, a method of application, or employment of any physical agent.

*Motor Generator, or Motor Converter.* Forms of a rotary machine comprising a motor driven by electricity from an outside source, the motor being coupled to a dynamo which being driven generates another current. The driving current may be of alternating character and the generated current continuous, or *vice versa;* or the machine may be used to change the voltage, or amperage, or frequency, or phase of a current by means of differential windings on the motor and dynamo respectively. Sometimes a motor-generator has the differential windings on one core with two commutators, or sets of collecting rings.

*Morton Wave Current.* A high potential static current which may be of oscillatory or pulsating character with intervals between succeeding oscillations or pulsations, and rise and fall of amperage.

*Ohm.* Practical unit of resistance opposing current flow. The legal ohm (Paris Congress of 1884) is the resistance offered by a column of

mercury 106 centimeters high and one square millimeter in cross section, at 0° C.; about the resistance of 100 meters of No. 8 telegraph wire.

*Ohm's Law.* The strength of the current varies directly as the applied electro-motive force, and inversely as the resistance of the circuit; or, the current, expressed in amperes, equals the electro-motive force, in volts, divided by the resistance in ohms $\left(C=\frac{V}{R}\right)$

*Oscillating Current.* A current alternating in direction, and of either increasing or decreasing amplitude or amperage.

*Oscilloscope.* An instrument, in the form of a vacuum tube, used for indicating by means of light, produced when passing a current through it, whether the current is unidirectional or alternating.

*Oudin Current.* A unipolar current of high frequency administered from a solenoid "step-up" attached to one end of a d'Arsonval solenoid.

*Parallel or Multiple Arc Windings, or Connections,* are distinguished from *series* connections, in that they are individually and directly connected from one main conductor to the other and are supplied with current separately and simultaneously instead of successively.

*Periodicity.* The rate of rise and fall or interruption of a unidirectional current, in contradistinction to the frequency of an alternating current.

*Phoresis.* Ionic transmission of bodies, electro-positive or electro-negative, into the tissues.

*Potential.* The condition of electrical tension in a body, manifested by the production of electrical effects in other bodies of different potential, or in a different state of electrical tension. When two bodies of different potential are brought together a current passes from the high to the low potential until the two are of equal potential, when electrical action ceases. In common usage in medical literature instead *of voltage* when the electrical tension or pressure is high.

*Pulsating Current.* A unidirectional current with a rapidly varying value in amperage, the rate of which is designated *periodicity.*

*Radiant Energy.* The energy exerted by radiating lines of light in the ether, comprising in therapeutics the Roentgen ray and the visible and invisible spectrum.

*Resistance.* The opposing influence of a body (solid, liquid or gaseous) to the expenditure of electrical potential. It is expressed in ohms; one ohm of resistance will permit the flow of a current of one ampere as the result of a pressure of one volt. The effect of the expenditure of electrical energy in resistance is to make it appear as heat.

*Resonator.* A device for increasing and regulating the potential of oscillations in high frequency currents; it consists of a series of open-wound convolutions of stiff wire, depending upon the air for their mutual insulation, in series with a condenser and a spark gap into which a high-potential current is passed, this causing interinduction



between the convolutions, and increasing and diminishing the potential as desired. (See body of work.)

*Rheostat.* A device for introducing resistance into an electrical circuit, usually so constructed as to permit of variations of its effective value by means of a switch or short-circuiting attachment. For example, a conductor of 100 ohms resistance connected to a source of 100 volts applied potential, will permit a current of 1 ampere to flow. To reduce this current to ½ ampere, the resistance of the circuit may be increased to 200 ohms, by inserting 100 ohms additional by means of a rheostat.

*Rheotome.* An instrument for automatically and rhythmatically making and breaking a current: an interrupter with an adjustable speed control.

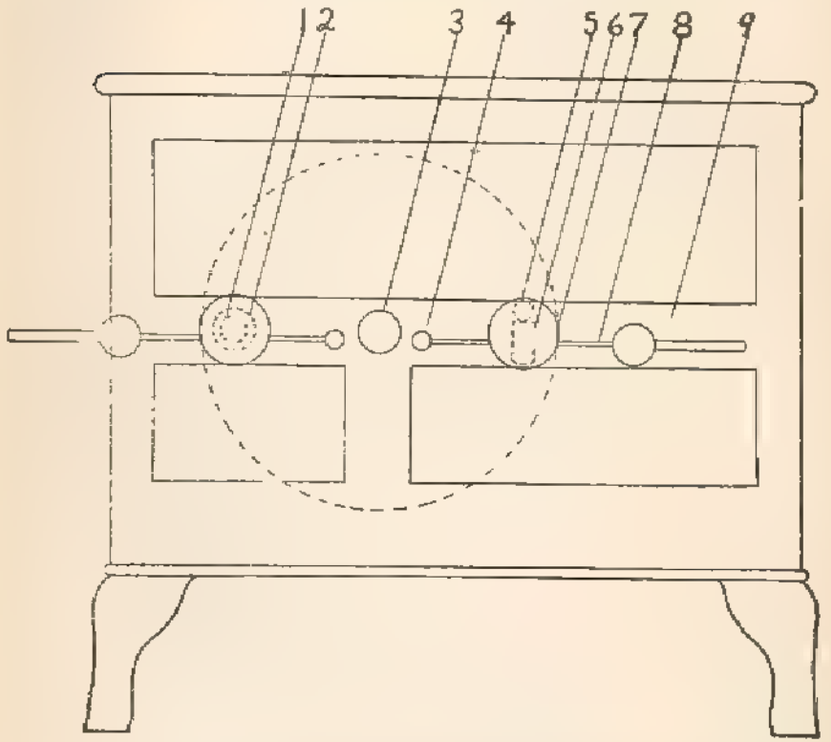


FIG. 62. Static Machine, Parts of.

1, Pole Pieces; 2, Pole Piece Washers and Nuts; 3, Rosette; 4, Slide Rod Balls; 5-6, Junction Piece; 7, Large Balls; 8, Slide Rod; 9, Charger, Connector, Hook, and Plug.

*Rhumkorff Coil.* A form of transformer of interrupted direct current of a low voltage, to a current of high voltage with varying characteristics, depending upon the *make and break* of the primary circuit or upon a primary current of rapidly changing values, or upon other circuit conditions.

*Series* winding or connection is one in which the current traverses the conductor sections and translating devices *successively.*

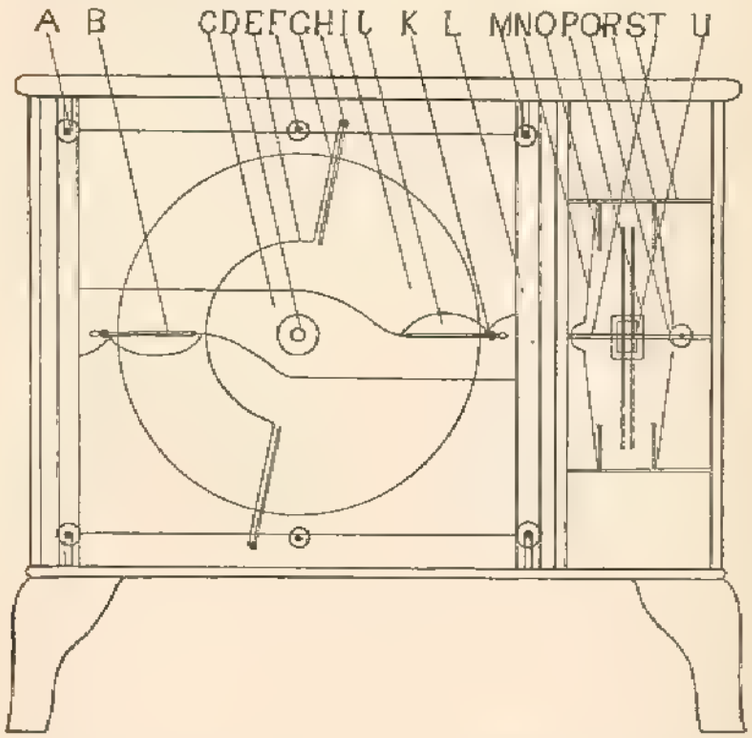


FIG. 63. Parts of Static Machine.

A-F, Stationary Supports; B-G, Comb Holders; C, Window of Machine or Vertical Space between Stationary Plates; D, Shaft; E, Neutralizing Rod; H, Long Comb Holder Supports; I, Straight Plates; J, Gilt Papers Armature; K, Short Comb Holder Supports; L, Stationary Uprights; M, Stationary Support Washers; N, Charger Neutralizers; O, Charger Brush Holders; P, Charger Hub Nut; Q, Charger Gears; R, Charger Comb Holders; S, Charger Brush Holder Supports; T, Shaft; U, Charger Hubs.



*Short Circuit.* Cutting out the whole or a section of an electric circuit by bridging it by a path of relatively low resistance. When a circuit is bridged, and that part of it beyond the bridge rendered dead, the bridge is called a *dead short-circuit.*

*Sinusoidal Current.* An alternating current diagrammatically indicated by a true sine wave curve.

*Spark Gaps.* Arrangement of points or surfaces between which a spark of electricity may jump. An adjustable gap between needle points, is used as a measure of very high potentials. The A. I. E. E. standard is 50,000 volts for the first inch in dry clear air.

*Tesla Current.* A current of enormous frequency, very high voltage but very low amperage, administered through one conductor with earth return. (See body of work.)

*Transformer (or Static Transformer).* A static device consisting of two insulated windings on an iron core, for changing by induction the ratio of voltage and amperage of alternating currents (only). An ideal (100% efficiency) transformer having its primary and secondary windings proportioned in the ratio of 1 to 1000, would change a primary current of 100 volts and 10 amperes transmitted to its primary, into a secondary current of 100,000 volts and 10 milliamperes. A closed-magnetic-transformer is one in which the iron magnetic core is formed into an unbroken iron circuit.

*Unidirectional.* In one direction.

*Unit.* The commercial term used to express the value of electricity in terms of voltage multiplied by amperage multiplied by time: thus, 100 volts × 10 amperes × 1 hour equals 1 unit; or 200 volts × 5 amperes × 5 hours equals 5 units. This is the basis on which commercial currents are metered.

*Unipolar.* Of one polarity, not alternating.

*Valve Tube.* A device, in the form of a vacuum tube, for damping out alternate (opposed) half-waves from a current which it is desired to render truly unidirectional.

*Volt.* The unit of pressure or electro-motive force impressed upon or applied to a circuit, and tending to produce a current.

*Voltage.* Difference of electrical potential; the analogue of difference of pressure in hydrostatics or hydraulics.

*Voltmeter.* An instrument, calibrated to indicate volts of potential difference between the points in the circuit at which it is connected.

*Watt.* The product of the voltage by the amperes. With a 110 volt current of 5 amperes we have 110 volts × 5 amperes equals 550 Watts.

# INDEX

PLATE I. Auto-condensation method.

HIGH POTENTIAL AND HIGH FREQUENCY CURRENTS

SNOW